

Final Task F
Stage I – Part 2 Pilot Test Work Plan for
Volatile Organic Compound-Containing
Alluvial Aquifer Groundwater

Burlington Northern Livingston Shop Complex
Livingston, Montana

BNSF Railway Company

K/J 0896021.16

June 2008

Kennedy/Jenks Consultants

**FINAL TASK F STAGE I – PART 2 PILOT TEST WORK PLAN FOR VOLATILE
ORGANIC COMPOUND-CONTAINING ALLUVIAL AQUIFER GROUNDWATER
Burlington Northern Livingston Shop Complex**

Revision Tracking Form

Submittal Date	Revision Date	Revision No.	Pages to be Replaced	Comments
11 July 2008	July 2008	2	Figure 3 Page 5-8 Page 5-13 Page 6-1 Pages 6-5 and 6-6 Page 7-2 Appendix H Table - Page 1 of 10	Prepared in response to DEQ comments dated 2 July 2008.

Notes:

- 1) Insert this tracking form in the front of the *Final Task F Stage I – Part 2 Pilot Test Work Plan for Volatile Organic Compound-Containing Alluvial Aquifer Groundwater*, dated June 2008.
- 2) New information to be added (shaded green).

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11 July 2008

Ms. Aimee Reynolds
Project Officer
Remediation Division
Montana Department of Environmental Quality
1100 North Last Chance Gulch
Helena, Montana 59601

Subject: Response to Comments - Final Task F Stage I – Part 2 Pilot Test Work Plan
for VOC-Containing Alluvial Aquifer Groundwater
Burlington Northern Livingston Shop Complex - Livingston, Montana
K/J 0896021*16

Dear Ms. Reynolds:

On behalf of the BNSF Railway Company (BNSF), Kennedy/Jenks Consultants is please to submit the attached revision pages (Revision No. 2) to the *Final Task F Stage I – Part 2 Pilot Test Work Plan for VOC-Containing Alluvial Aquifer Groundwater*. The revision pages address comments in Montana Department of Environmental Quality's (DEQ's) letter to BNSF dated 2 July 2008. The following table indicates how each comment is addressed.

DEQ Comment Number	Report Section Number	Report Section Title	Comment
--	Table 5	Table 5	The groundwater sampling program is summarized in Table 5. The scheduled sampling events are identified as follows: B = Baseline; W1, W2, etc. = Week 1, Week 2, etc. following injection; M1, M2, etc. = Month 1, Month 2, etc. following injection. For clarification, Week 4 (W4) = Month 1 (M1).
1	–	Figure 3	Soil borings 08-SB1 through 08-SB5 have been added to Figure 3, as required by DEQ.
2	Section 5.3.2.3	Formation and Attenuation of Chromium (Total and Hexavalent)	A control test (i.e., series of vials prepared with treated water, but no soil) was not performed for the chromium attenuation testing portion of the bench scale study. The control test was not performed because sodium permanganate [i.e., treated water contained residual sodium permanganate at conclusion of volatile organic compound (VOC) Oxidation and Water Quality Test; approximately 11 days] would not be consumed within the time frame of the chromium attenuation study. Therefore, a control test was not appropriate. Text has been modified accordingly.

Ms. Aimee Reynolds
 Montana Department of Environmental Quality
 11 July 2008
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DEQ Comment Number	Report Section Number	Report Section Title	Comment
3	Section 5.4.1.1	Oxidant Mass Calculation	No change. The sodium permanganate concentration is expressed as a percent by weight (2.5%) and as a percent by volume (2.86%). The values stated in the text have been confirmed as accurate.
4	Section 5.4.1.2	Fate and Transport of Permanganate and Soluble Metals	This comment has been addressed in the Attachment 1 to this letter.
5	Section 5.4.2.3	New NaMnO ₄ Injection Boreholes	As the injection borings (IW-01 through IW-04) will be completed on the exterior of the Electric Shop, concrete coring will not be required. It is also anticipated borings conducted for collection of pre- and post-injection soil samples will also be conducted on the exterior of the Electric Shop. Text referring to "concrete coring will likely be required within the Electric Shop" has been removed.
6	Section 6.1	Injection Process Monitoring	During borehole advancement for the four designated injection borings, soil samples will be collected for analysis from: immediately beneath the concrete slab and fill material; 10 feet beneath the slab; immediately above the water table in the vadose zone; and in the saturated zone where primary treatment is expected to occur (total of 4 samples per injection boring). Text has been added to Section 6.1 to satisfy DEQ's request of soil sample collection within the saturated zone.
	Section 6.2.3	Baseline and Confirmation Groundwater Monitoring	Based on communication with Kent Sorenson (CDM), soil sampling as described in Section 6.2.3 (last paragraph) appears to be partially redundant to soil sampling as described in Section 6.1. Therefore, text in Section 6.2.3 has been revised to state the following: Confirmation soil samples (within close proximity to the water table and within the saturated zone where primary treatment is expected to occur) will be conducted only if baseline samples exceed the ROD-specified cleanup levels. The baseline samples refer to soil sample collection as described in Section 6.1 (i.e., soil samples collected immediately above the water table and within the saturated zone). If VOCs are found above ROD-specified cleanup levels in the baseline samples, then two confirmation borings will be drilled at the end of the pilot study as close as practicable to the baseline borings, and will be sampled in the same manner.
	Section 7.0	Data Analysis and Evaluation	Next to last bullet has been modified to include saturated zone soil VOC concentrations.

Ms. Aimee Reynolds
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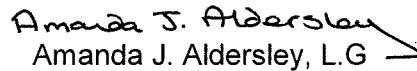
DEQ Comment Number	Report Section Number	Report Section Title	Comment
7	Appendix H	Table	A reference to Attachment 1 to this letter has been added to the three sections on Page 1 of Appendix H table, as required by DEQ.
8	Appendix H	Table	Paragraph has been deleted from Page 1 of Appendix H table and replaced with DEQ's required text.

If you have any questions regarding these revisions, please contact us at (253) 874-0555.

Very truly yours,

KENNEDY/JENKS CONSULTANTS


John E. Norris, R.G.
Project Manager


Amanda J. Aldersley, L.G.
Assistant Project Manager

Enclosures:

Attachment 1: Metals Fate and Transport

Table 1-1: Long-term Hexavalent Chromium Attenuation

Table 1-2: Task F Stage I – Part 2: Bromide Tracer Test – Preliminary Analytical Results

Revision Pages (Revision No. 2)

cc: Dave Smith, BNSF
Catherine Laughner, Browning, Kaleczyc, Berry & Hoven
Katherine Haque-Hausrath, Montana Department of Environmental Quality
Steve Caldwell, Park County Environmental Council
Mark Johnson, RTI, Inc.

ATTACHMENT 1

METALS FATE AND TRANSPORT

1.1 HEXAVALENT CHROMIUM

1.1.1 Chromium Attenuation Bench-Scale Study Summary and Results

The long-term fate of hexavalent chromium was performed on soil and groundwater segregated from both the low (0.5 g NaMnO₄/kg soil; 250 mg/L NaMnO₄/L) and high (1.5 g NaMnO₄/kg soil; 1,500 mg/L NaMnO₄/L) dosages for the volatile organic compound (VOC) destruction and water quality testing portion of the bench scale study. At the conclusion of the VOC destruction and water quality testing portion of the bench scale study, the treated water and treated soil for the low and high dosages were segregated. For 15 days, the treated water and treated soil remained preserved in this condition at which time the hexavalent chromium test reactors were prepared. A series of four jars representing “treatment zone” conditions were prepared with 50 g treated soil and 25 mL treated groundwater. A series of four jars representing “downgradient” conditions were prepared with 50 g untreated soil and 25 mL treated water. The prepared reactors were paced on a shaker table.

Once the NaMnO₄ had disappeared from a given series, periodically a replicate from the series was destructively sampled and analyzed for hexavalent chromium. Note: The time required for NaMnO₄ to be fully consumed varied for each series (see Table 1-1, attached). Observations specific to the low dosage hexavalent chromium testing (i.e., applicable to field injection loading of 0.5 g NaMnO₄/kg soil) are as follows:

- At the end of the VOC Oxidation and Water Quality Testing portion of the bench scale study, dissolved chromium (assumed all hexavalent chromium) in the low dosage was detected at 0.126 mg/L. These levels reflect hexavalent chromium concentrations at Day 11.

- For the low dosage test (both “treatment” and “downgradient” reactors), NaMnO_4 was observed to be fully consumed within 12 days after reactor preparation of the attenuation tests (total of $11 + 12 = 23$ days).
- The hexavalent chromium concentration in the low dosage “treatment” reactor was higher at “Time 0” than in “VOC Destruction Test – Day 11” which may suggest that the amount of hexavalent chromium formed is related to the contact time between the NaMnO_4 and the soil.
- For the low dosage tests (both “treatment” and “downgradient” reactors), the hexavalent chromium concentration decreased dramatically within 7 days. Hexavalent chromium was not detected (< 0.01 mg/L) at day 20 in the low dosage “downgradient” reactor. This suggests that site soil in the absence of NaMnO_4 possess the ability to attenuate hexavalent chromium.

Note: Following the VOC Oxidation and Water Quality Test, the soil and water was segregated and stored for 15 days prior to preparation of hexavalent chromium attenuation tests. The 15 days are not included in the time required for full consumption of NaMnO_4 . The 15 days is not included as the water was not in direct contact with soil during this period.

A control test (i.e., series of vials prepared with treated water, but no soil) was not performed for the chromium attenuation testing portion of the bench scale study. The control test was not performed because NaMnO_4 (i.e., treated water contained residual NaMnO_4 at the conclusion of VOC Oxidation and Water Quality Test; approximately 11 days) would not be consumed within the time frame of the chromium attenuation study. Therefore, a control test was not appropriate.

1.1.2 Hexavalent Chromium Fate and Transport

The Circular DEQ-7, Montana Numeric Water Quality Standard (DEQ-7 standard) for total chromium is 0.1 mg/L. The time required for hexavalent chromium to attenuate is

highly dependent on observation of full consumption of NaMnO_4 . On a bench scale level, NaMnO_4 was consumed within 23 days. The results of the bench-scale study suggest site soils in the absence of NaMnO_4 possess the ability to attenuate hexavalent chromium.

In the field, it is expected full consumption of NaMnO_4 will be observed faster than indicated on a bench scale level due to mixing. The injection process will be controlled (i.e., injection volume approximately 12% of target pore volume, low injection rate and pressure, top down delivery over 3 to 5 foot intervals, etc.) to achieve mixing and greater contact with site soils. Field monitoring during the injection process will also be conducted to observe NaMnO_4 consumption and transport, with modifications potentially made to the injection scheme based on observed response.

Assuming a groundwater seepage velocity of 4.6 feet/day [as an assumption discussed with Kent Sorenson (CDM); as stated in Table 5 of *Final Task F Stage I – Part 2 Pilot Test Work Plan for VOC-Containing Alluvial Aquifer Groundwater*] and NaMnO_4 consumption within 23 days, the transport distance is estimated at approximately 106 feet downgradient of the injection point (in general, upgradient of monitoring wells 07-15, 08-2, and 07-14). It is anticipated hexavalent chromium (if generated through oxidation) will attenuate within the boundaries of the groundwater monitoring well network bounded to the east by the transfer table (see Figure 3 of *Final Task F Stage I – Part 2 Pilot Test Work Plan for VOC-Containing Alluvial Aquifer Groundwater*). Post-injection groundwater monitoring will include collection of groundwater samples for dissolved chromium (assumed hexavalent chromium) to assess attenuation within and downgradient of the zone of oxidation.

1.2 MANGANESE

The DEQ-7 standard for Montana's surface and groundwater contain a secondary maximum contaminant level (MCL) for manganese in groundwater of 0.05 mg/L. The EPA unified screening level (SL) for tap water is 0.88 mg/L (Oakridge National

Laboratory 2008). The calculation of manganese concentrations and transport distance is described as follows:

- Manganese is 39% the total weight of sodium permanganate; therefore, a 2.86 NaMnO₄ injection solution (28,600 mg/L) equates to a manganese concentration of 11,150 mg/L (as conservative, neglected production of manganese oxide).
- Utilizing data from well 07-16, bromide was detected on 7 May 2008 (first detection) and 18 May 2008 (last sampling event) at concentrations of 10 and 0.2 mg/L, respectively (see Table 1-2, attached). Utilizing the first order equation, “k” (lumped parameter for advection and dispersion) is estimated at 0.35 day⁻¹. Applying the same equation, k value, initial manganese concentration of 11,150 mg/L, and secondary MCL manganese concentration of 0.05 mg/L, the time is calculated at 35 days. Assuming a groundwater seepage velocity of 4.6 feet/day (as noted in Table 5 of *Final Task F Stage I – Part 2 Pilot Test Work Plan for VOC-Containing Alluvial Aquifer Groundwater*), the maximum downgradient transport equating to a manganese concentration of 0.05 mg/L is estimated at 160 feet (immediately upgradient of monitoring well 07-14) (for SL manganese concentration of 0.88 mg/L, the maximum downgradient transport distance is estimated at 125 feet).
- During NaMnO₄ oxidation of organics or other reductants in the subsurface, manganese oxide (MnO₂) solids are produced. For example, during the mineralization of PCE, 1 mole of MnO₂ is produced for each mole of NaMnO₄ consumed. Therefore, it is expected manganese will attenuate readily within the monitoring well network.

REFERENCES

Oakridge National Laboratory, Managed by UT Battelle for Department of Energy, 2008.
<http://epa-prgs.ornl.gov/chemicals/download.shtml>

TABLE 1-1

LONG-TERM HEXAVALENT CHROMIUM ATTENUATION
Burlington Northern Livingston Shop Complex

Time (days)	Cr(VI) (mg/L)	Specific Notes
Low Dose NaMnO₄, Treatment Zone VOC Destruction Test - Day 11		NaMnO ₄ consumed 12 days after completion of VOC Destruction and Water Quality Testing. Total oxidation time of 23 days.
0	0.126	
7	0.209	
20	0.135	
40	0.03	
	0.012	
Low Dose NaMnO₄, Downgradient VOC Destruction Test - Day 11		NaMnO ₄ consumed 12 days after completion of VOC Destruction and Water Quality Testing. Total oxidation time of 23 days.
0	0.126	
7	0.015	
20	0.011	
40	< 0.01	
	< 0.01	

General Notes:

1. "VOC Destruction Test - Day 11" is the dissolved chromium concentration (assumed all hexavalent chromium) in the Day 11 VOC Destruction and Water Quality Testing portion of bench scale study.
2. "0 Days" is the time residual NaMnO₄ had been consumed.
3. Subsequent times (i.e., 7 and 20 days) represent days following NaMnO₄ consumption.

mg/L - milligrams per liter

TABLE 1-2

TASK F STAGE I - PART 2: BROMIDE TRACER TEST - PRELIMINARY ANALYTICAL RESULTS
Burlington Northern Livingston Shop Complex

Well Designation	Bromide (mg/L) ^(a)													
	5-May-08	6-May-08	7-May-08	8-May-08	9-May-08	10-May-08	11-May-08	12-May-08	13-May-08	14-May-08	15-May-08	16-May-08	17-May-08	18-May-08
07-16	<0.1 ^(b)	<0.1	10.0	7.0	5.5	5.4	5.2	2.7	5.1	5.0	0.4	0.2	0.2	0.2
07-2A	<0.1/<0.1 ^(c)	6.3/6.2	5.3/5.3	5.1/5.1	5.1	5.0	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2
07-2B	<0.1	6.3	5.2	5.1	0.4	0.3	0.3	0.2	0.2	0.2	0.3	0.1	<0.1	0.1
89-3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1/<0.1	<0.1	<0.1/<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
07-13	<0.1	<0.1	14.9	8.8	7.8/7.9	7.2	6.8/6.9	6.2	6.0	5.7	5.5	1.3	1.2	1.1
07-14	<0.1	22.9	15.4	10.7	9.3	8.6	8.0	7.3	6.8	6.5	6.3	2.7	2.3	2.0
07-15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1/<0.1	<0.1	<0.1/<0.1	<0.1	<0.1/<0.1
08-2	<0.1	5.0	5.0	0.4	0.3	0.3	0.2	0.2	0.3/0.2	0.2	0.2/0.2	0.1	0.1/0.1	0.1
Slug1 ^(d)	1,260	NA ^(e)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Slug2 ^(d)	1,220	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Water Quality Parameters (mg/L) ^(f)	Well 07-16 5-May-08
Alkalinity, Total as CaCO3	235
Chloride	12
Sulfate	44
Sulfide	<0.04
Dissolved Organic Carbon (DOC)	1.1
Nitrogen, Nitrite as N	<0.05
Nitrogen, Nitrate as N	1.14
Nitrogen, Nitrate+Nitrite as N	1.14
Calcium	80
Iron	<0.03
Magnesium	17
Potassium	2
Sodium	29
Total suspended solids (TSS)	<10
Total dissolved solids (TDS)	355

Notes:

- (a) Samples were analyzed for bromide using EPA Method 300.0.
- (b) "<" denotes analyte was not detected at the indicated method reporting limit.
- (c) Duplicate sample result.
- (d) Sample collected from bromide solution used in bromide tracer test.
- (e) "NA" denotes not analyzed.
- (f) Samples were analyzed for water quality parameters as follows:
 - Alkalinity using SM 2320B
 - Chloride and Sulfate using EPA Method 300.0
 - Sulfide using SM 4500S-D
 - Dissolved organic carbon using SM 5310C
 - Nitrogen, Nitrite as N using EPA Method 353.2
 - Nitrogen, Nitrate as N using EPA Method 353.2
 - Nitrogen, Nitrite+Nitrate as N using EPA Method 353.2
 - Calcium, iron, magnesium, potassium, and sodium using EPA Method 200.7
 - Total dissolved solids (TDS) and total suspended solids (TSS) using SM 2540C and D, respectively.

Detected values are shown in bold.

mg/L - milligrams per liter

PRELIMINARY DATA HAS NOT BEEN VALIDATED.

Kennedy/Jenks Consultants

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23 June 2008

Ms. Aimee Reynolds
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1100 North Last Chance Gulch
Helena, Montana 59601

Subject: Final Task F Stage I – Part 2 Pilot Test Work Plan
for VOC-Containing Alluvial Aquifer Groundwater
Burlington Northern Livingston Shop Complex - Livingston, Montana
K/J 0896021*16


Dear Ms. Reynolds:

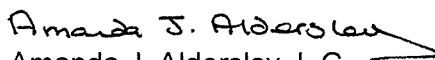
On behalf of the BNSF Railway Company (BNSF), Kennedy/Jenks Consultants is please to submit four (4) hard copies and one (1) electronic copy of the *Final Task F Stage I – Part 2 Pilot Test Work Plan for VOC-Containing Alluvial Aquifer Groundwater*. This work plan was initially prepared by Kennedy/Jenks Consultants on behalf of BNSF in March 2006 and subsequently reviewed and edited by the Montana Department of Environmental Quality (DEQ). DEQ additions and modifications provided electronically on 22 May 2008 are underlined in the document. Other modifications to the document were mutually agreed upon in conversations between Kennedy/Jenks Consultants and CDM (DEQ's consultant). A redline strikeout copy these mutually agreed upon modifications were provided to DEQ with this document (under separate cover).

If you have any questions regarding this document, please contact us at (253) 874-0555.

Very truly yours,

KENNEDY/JENKS CONSULTANTS


John E. Norris, R.G.
Project Manager


Amanda J. Aldersley, L.G.
Assistant Project Manager

Enclosures

cc: Dave Smith, BNSF
Catherine Laughner, Browning, Kaleczyc, Berry & Hoven
Katherine Haque-Hausrath, Montana Department of Environmental Quality
Steve Caldwell, Park County Environmental Council
Brian Blicher, RTI, Inc.

**FINAL TASK F
STAGE I – PART 2 PILOT TEST WORK PLAN
FOR VOLATILE ORGANIC COMPOUND-CONTAINING
ALLUVIAL AQUIFER GROUNDWATER**

**Burlington Northern Livingston Shop Complex
Livingston, Montana**

Prepared for

BNSF RAILWAY COMPANY

Prepared by

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June 2008

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LIST OF ACRONYMS

<u>Abbreviation</u>	<u>Description</u>
bgs	below ground surface
BN	Burlington Northern
BNSF	BNSF Railway Company
BRA	baseline risk assessment
Carus	Carus Chemical Company
CECRA	Comprehensive Environmental Cleanup and Responsibility Act
cis-1,2-DCE	cis-1,2-dichloroethene
COC	chemical of concern (COCs for plural)
Cr ³⁺	trivalent chromium
Cr ⁶⁺	hexavalent chromium
DCE	dichloroethene
DEQ	Montana Department of Environmental Quality
DNAPL	dense non-aqueous phase liquid
EPA	U.S. Environmental Protection Agency
ERCL	environmental requirement, criterion, and limitation (ERCLs for plural)
ft/day	feet per day
ft/ft	feet per foot
ft/sec	feet per second
FS	feasibility study
gpm	gallons per minute
HASP	Health and Safety Plan
IDW	investigation-derived waste
kg	kilogram
KMnO ₄	potassium permanganate
LRC	Livingston Rebuild Center
MCA	Montana Code Annotated
mg/L	milligrams per liter
mM	millimolar
MNA	monitored natural attenuation
MnO ₂	manganese dioxide
MnO ₄	permanganate
Mn ²⁺	reduced manganese ion
MSDS	material safety data sheet
MRL	Montana Rail Link
NaMnO ₄	sodium permanganate
NAPL	non-aqueous phase liquid
NAVD 88	North American Vertical Datum 1988
NCA	North Creek Analytical
NOD	natural oxidant demand
nm	nanometer
ORP	oxidation-reduction potential
PCE	tetrachloroethene

Revision No. 1

June 2008

0896021.16

LIST OF ACRONYMS

<u>Abbreviation</u>	<u>Description</u>
PID	photoionization detector
PPE	personal protective equipment
ppm	parts per million
PRIMA	PRIMA Environmental of Sacramento, California
psi	pounds per square inch
psig	pounds per square inch gauge
QAPP	Quality Assurance Project Plan
QA	quality assurance
QC	quality control
RA	remedial action
RD	remedial design
ReTech	Remediation Technologies
RI	remedial investigation
ROD	Record of Decision
ROI	radius of influence
SAP	Sampling and Analysis Plan
SOD	soil oxidant demand
SOG	Standard Operating Guideline (SOGs for plural)
SOP	Standard Operating Procedures (SOPs for plural)
SOW	Statement of Work
SVE	soil vapor extraction
TCE	trichloroethene
TDS	total dissolved solids
trans-1,2-DCE	trans-1,2-dichloroethene
VOC	volatile organic compound (VOCs for plural)
WWTP	wastewater treatment plant
WQB-7 standards	Montana Numeric Water Quality Standards for Human Health (renamed DEQ-7 standards in February 2006)
µg/L	micrograms per liter
µm	micron
UIC	Underground Injection Control
1,4-DCB	1,4-dichlorobenzene

1.0 INTRODUCTION

This *Task F Stage I – Part 2 Pilot Test Work Plan for Volatile Organic Compound (VOC)-Containing Alluvial Aquifer Groundwater* (pilot test work plan) addresses the Stage I – Part 2 requirements for remedial design/remedial action (RD/RA) activities under “Task F: Alluvial Aquifer VOC Cleanup” of the *Statement of Work for Spring 2005 Activities* dated August 2005 (Spring 2005 SOW) [Montana Department of Environmental Quality (DEQ 2005c)]. BNSF Railway Company (BNSF) requested that this pilot test be included in the Spring 2005 SOW to evaluate the means by which to accelerate groundwater remediation at the Facility. This work plan was initially prepared by Kennedy/Jenks Consultants on behalf of BNSF in March 2006 and subsequently reviewed and edited by DEQ. DEQ additions and modifications provided electronically on 22 May 2008 are underlined in the document. The Burlington Northern (BN) Livingston Shop Complex site is being addressed under Montana’s Comprehensive Environmental Cleanup and Responsibility Act (CECRA), which defines a “Facility” to include “any site or area where a hazardous or deleterious substance has been deposited, stored, disposed of, placed or otherwise come to be located” [Section 75-10-701(4)(a)(ii), Montana Code Annotated (MCA)].

Consistent with this definition, the BN Livingston Shop Complex Facility (the Facility) includes the Livingston railyard and the surrounding area where hazardous or deleterious substances as defined under CECRA have been deposited, stored, disposed of, placed, or otherwise come to be located. The Facility is located in Park County, Montana, with the majority of it within the City of Livingston. Livingston is approximately 23 miles east of Bozeman, Montana, and 119 miles west of Billings, Montana. The Facility location is shown on Figure 1. A copy of the Facility location map from the *Record of Decision* (ROD) (DEQ 2001) is also provided in the ROD figures section of this pilot test work plan, as required by DEQ. Main features of the Livingston railyard portion of the Facility are shown on Figure 2.

The DEQ has selected a remedial action for the Facility based on the results of a remedial investigation (RI) (Envirocon 1994), feasibility studies (FSs) (Envirocon 1998a,b), and a baseline risk assessment (BRA) (Camp Dresser & McKee 1993). The selected remedial action for the Facility is set forth in the ROD (DEQ 2001). The selected remedy for chlorinated VOCs in groundwater in the alluvial aquifer is removal of source(s) to groundwater followed by monitored natural attenuation (MNA). A contingency remedy requires active groundwater treatment in source areas using localized pump-and treat systems if cleanup levels will not be met within twenty years under MNA.

The Spring 2005 SOW (DEQ 2005c) addresses requirements and activities for initiating high priority portions of the selected remedy. Other activities required to implement the ROD will be addressed at a later date. This pilot test work plan has been prepared to satisfy the RD/RA requirements identified in the following sections of the ROD and Spring 2005 SOW:

- ROD Section X.C – VOC-Containing Groundwater
- Spring 2005 SOW Section 3.1.6 – Task F: Alluvial Aquifer Groundwater VOC Cleanup.

The VOCs identified in the ROD as chemicals of concern (COCs) with cleanup levels are: tetrachloroethene (PCE); trichloroethene (TCE); cis-1,2-dichloroethene (cis-1,2-DCE); vinyl chloride; chlorobenzene; 1,4-dichlorobenzene (1,4-DCB); and trans-1,2-dichloroethene (trans-1,2-DCE).

Based on historical groundwater analytical data, source removal of VOC-contaminated sludge and soils followed by MNA was selected for remediation of chlorinated VOCs at the Facility. A contingency remedy requires active groundwater treatment in source areas using localized pump-and treat systems if cleanup levels will not be met within twenty years under MNA. The *Task F Stage I – Part 1 Remedial Action Plan for VOC-Containing Alluvial Aquifer Groundwater* (DEQ 2007) (Stage I – Part 1 RA Plan) has

been submitted to DEQ to address the continued acquisition of monitoring data to evaluate chlorinated VOC natural attenuation. The Stage I – Part 1 RA Plan consists of establishing a Task F groundwater monitoring network that requires installation of 14 new monitoring wells; collection and analysis of groundwater samples quarterly for at least one year; and updating the private and public well inventory (initially approved in August 2006). During the implementation of Part 1 activities, Stage I – Part 2 RD/RA activities are planned. Stage I - Part 2 activities involve testing of one or more selected remediation technologies to evaluate their efficacy in promoting the attainment of ROD cleanup levels. This pilot test work plan has been prepared to address the Stage I – Part 2 RD/RA requirements.

1.1 DESCRIPTION OF TASK F

Task F will be conducted in stages and addresses the portion of the selected remedy for chlorinated VOC-containing groundwater in the alluvial aquifer. The purposes of Stage I RD/RA activities are to (1) further delineate chlorinated VOC distributions and evaluate potential stratification of chlorinated VOC concentrations in groundwater in the alluvial aquifer, (2) establish a groundwater monitoring well network for chlorinated VOCs, and (3) evaluate long-term performance of natural attenuation for remediating chlorinated VOCs in groundwater. Stage I also includes pilot testing one or more selected remediation technologies to evaluate their efficacy in promoting the attainment of ROD cleanup levels for chlorinated VOCs in groundwater. Stage II RD/RA activities are to be addressed at a later date and will provide the long-term remedy for cleaning up chlorinated VOCs in the alluvial aquifer.

Groundwater in the alluvial aquifer at the Facility contains chlorinated VOCs that exceed ROD cleanup levels. Task F addresses chlorinated VOC-containing groundwater in the alluvial aquifer; the potential presence of chlorinated VOCs in the groundwater in the bedrock aquifer(s) is being addressed in Task L. [Refer to *Task L Supplemental Investigation Work Plan for Bedrock Aquifer(s)* (Kennedy/Jenks Consultants 2005a). Note: This document is currently pending DEQ review and approval.] The selected

remedy for chlorinated VOCs in groundwater in the alluvial aquifer is removal of source(s) to groundwater followed by MNA. A contingency remedy requires active groundwater treatment in source areas using localized pump-and treat systems if cleanup levels will not be within twenty years under MNA. Task F focuses on natural attenuation, coupled with pilot testing of technology(ies) to enhance groundwater remediation. The natural attenuation processes for chlorinated VOCs in groundwater at the Facility include dilution, dispersion, and adsorption. While minor reductive dechlorination might be observed following chemical oxidation, it will be localized and will not impact the greater plume. Source removal work was conducted during previous interim actions at the Facility (refer to Section 2.4).

1.1.1 Stage I – Part 1

Based on the historical groundwater monitoring data, DEQ required the collection of additional groundwater quality data to further delineate the area of groundwater containing chlorinated VOCs with concentrations at or exceeding the Circular DEQ-7 Montana Numeric Water Quality Standards (DEQ-7) required reporting limit upgradient of the vapor degreaser pit source area, and within the downgradient western, eastern, and northern portions of the apparent area in which groundwater contains VOC concentrations at or greater than the DEQ-7 required reporting limit. DEQ also required BNSF to extend its groundwater monitoring well network to include wells to the northeast to delineate the downgradient extent of chlorinated VOC-containing groundwater at or exceeding DEQ-7 required reporting limits. DEQ also required additional data regarding stratification of PCE concentrations within the alluvial aquifer, particularly downgradient of the chlorinated VOC source areas. These requirements are addressed in the Stage I – Part 1 RA Plan (DEQ 2007).

1.1.2 Stage I – Part 2

BNSF requested the pilot testing specified in Task F and has prepared this pilot test work plan to describe the pilot test to be performed. This pilot test work plan is submitted separately from, and after, submittal of the Stage I – Part 1 RA Plan (DEQ 2007). However, Parts 1 and 2 may overlap such that pilot testing begins before submittal of the Stage I – Part 1 RA report. BNSF will conduct pilot test activities in compliance with the approved pilot test work plan and will prepare annual monitoring reports. The pilot test work plan will specify monitoring to evaluate the efficacy of the technology being tested.

After a minimum of 1 year's quarterly monitoring using the groundwater monitoring well network established in Stage I – Part 1 and the receipt of sufficient pilot testing data to permit evaluation of the piloted technology, BNSF will submit a letter proposal to DEQ for use of a model(s) or other analytical technique(s) that considers site-specific information and data to evaluate the rate of remediation for chlorinated VOCs at the Facility. BNSF and DEQ will have a scoping meeting to discuss the models/techniques to be used, input parameters, and assumptions to be made. If DEQ approves use of the models/techniques, BNSF will use them to perform the analysis. When completed, BNSF will prepare a Stage I – Part 2 RA report that summarizes the activities conducted, data collected, the modeling/analysis performed including calibration results, sensitivity analyses, and the uncertainty with model predictions. DEQ will review the report and may provide additional evaluations. The Stage I – Part 2 RA report will also provide an updated private and public well inventory. DEQ will determine whether remediation of chlorinated VOCs is occurring or will occur at an acceptable rate using data provided in the Stage I - Part 1 and Part 2 RA reports and U.S. Environmental Protection Agency (EPA) guidance. In the time between the start of data evaluation activities and DEQ's decision regarding the remediation's effectiveness, BNSF will continue groundwater monitoring at the Facility in accordance with the Stage I – Part 1 RA Plan unless DEQ approves a different monitoring frequency.

1.2 OBJECTIVES

The objective of the pilot test described herein is to obtain data to evaluate the potential for the selected technology to reduce the concentrations of chlorinated VOCs in alluvial aquifer groundwater to below ROD cleanup levels within a reasonable time as defined by the ROD (20 years). The pilot test will target the source of VOCs at the former vapor degreaser pit located northwest of the Electric Shop building (in the general vicinity of well 89-3), since this location has been shown to be the most significant known source of VOCs in the alluvial aquifer.

Chemical oxidation using sodium permanganate is proposed in this work plan as the technology to be pilot tested. If the results of the pilot testing do not indicate that reduction of the chlorinated VOCs will be achieved within the ROD time frame, other applicable technologies will be proposed for testing.

In addition to characterizing the lateral extent of the effected groundwater, evaluating the potential for stratification of VOC concentrations, and evaluating MNA effectiveness, the monitoring well network established under the Stage I – Part 1 RA Plan is intended to provide periodic data to monitor temporal trends in the spatial distribution of chlorinated VOC concentrations in alluvial aquifer groundwater. Additional alluvial aquifer groundwater monitoring will be performed as described in Section 6.0 to support performance evaluation(s) of pilot testing and/or engineered groundwater remediation systems.

1.3 WORK PLAN ORGANIZATION

This pilot test work plan is organized as follows:

- Section 2.0 briefly summarizes previous groundwater investigative activities, monitoring data, and relevant interim actions and FS work. This section

cross-references specific documents that provide further information about previous groundwater investigations and interim remedial actions.

- Section 3.0 presents the selected remedy and ROD cleanup levels for chlorinated VOCs that have been identified in the alluvial aquifer groundwater at the Facility.
- Section 4.0 presents a description of the proposed remedy (in situ chemical oxidation using a permanganate oxidant).
- Section 5.0 summarizes the permanganate oxidation pilot test plan including objectives, technical approach, pilot test design, bench-scale testing and injection testing.
- Section 6.0 presents the pilot test-specific sampling and analysis plan (SAP). The pilot test-specific SAP is designed for use in conjunction with the Final Facility-Wide Sampling and Analysis Plan (Facility-Wide SAP) (Kennedy/Jenks Consultants 2006). [Note: The Facility-Wide SAP includes Standard Operating Guidelines (SOGs) and the Facility-Wide Quality Assurance Project Plan (QAPP)]. Upon DEQ approval of the pilot test-specific SAP, it will be attached as an addendum to the Facility-Wide SAP.
- Section 7.0 describes how data obtained from the pilot test will be evaluated/interpreted.
- Section 8.0 identifies specific deliverables associated with the Task F Stage I – Part 2 activities, as required by the Spring 2005 SOW.
- Section 9.0 addresses project management, data management, access/security, contingency procedures, and community relations.

- Section 10.0 addresses how investigation-derived waste (IDW) generated during implementation of the pilot test will be managed.
- Section 11.0 addresses health and safety requirements during implementation of the pilot test.
- Section 12.0 identifies any permits that may be required to implement the pilot test.
- Section 13.0 presents a preliminary schedule for implementation of the pilot test.
- Section 14.0 discusses how the pilot test complies with environmental requirements, criteria, and limitations (ERCLs).

This work plan was prepared following the requirements in Section 5.1.13 of the Spring 2005 SOW (Subtask 13: Remedial Design/Remedial Action Plan) and using EPA's *Guidance for Conducting Treatability Studies under CERCLA – Final* (EPA 1992).

2.0 SUMMARY OF PREVIOUS INVESTIGATIONS

This section summarizes previous alluvial aquifer groundwater investigations (including groundwater monitoring) and relevant interim remedial actions and FS work conducted at the Facility as they pertain to this pilot test work plan. Additional information is provided in the Stage I – Part 1 RA Plan (DEQ 2007) and other references cited in this section.

2.1 GROUNDWATER INVESTIGATIVE ACTIVITIES

Previous investigations performed at the Facility identified the sources and estimated distribution of chlorinated VOCs in the alluvial aquifer. On behalf of BNSF, ERT of Fort Collins, Colorado conducted initial groundwater investigations at the Facility in March 1986. From 1987 to March 1989, Remediation Technologies (ReTec) of Fort Collins, Colorado, on behalf of BNSF, conducted groundwater investigations. Envirocon, Inc. of Missoula, Montana, conducted Facility investigations in May 1989 and completed field investigations for the RI on behalf of BNSF.

As of May 2005, 143 investigation wells penetrating the alluvial aquifer (including monitoring and test wells) have been constructed during Facility groundwater investigations. Additional monitoring and multi-use wells were installed in 2006 and 2007. In addition, numerous extraction wells have been installed at the Facility as part of the soil vapor extraction (SVE) systems. Some of these SVE wells have been used as test wells for various groundwater remedial actions. Locations of the monitoring/test wells at the Facility and information regarding well construction can be found in the Stage I – Part 1 RA Plan (DEQ 2007) and on the July 2007 Facility map.

Monthly groundwater sampling of select wells was conducted from 1989 to June 1992. The groundwater sampling frequency was changed to quarterly beginning in August 1992, and this sampling schedule continued until the end of 1995. Semiannual/annual

groundwater monitoring commenced in 1996 and is ongoing. Kennedy/Jenks Consultants, on behalf of BNSF, began conducting semiannual monitoring in June 2003.

A summary of previous groundwater investigative activities at the Facility, including a chronology of well installations, groundwater sampling events, and other relevant work is provided in Table 1 of the Stage I – Part 1 RA Plan (DEQ 2007).

2.2 GROUNDWATER LEVEL DATA

The portion of the Facility targeted for the permanganate oxidation pilot test is located near the former vapor degreaser pit (northwest corner of the Electric Shop building) in the general vicinity of well 89-3. Well 89-3 is located inside the electric shop, approximately 60 to 90 feet northeast of the proposed treatment area. The boring log for well 89-3 indicates that the aquifer beneath the Electric Shop is composed of coarse sandy gravel and has a saturated thickness of 12 to 15 feet. Depth to bedrock in well 89-3 is 34 feet below ground surface. Historical water level measurements for well 89-3 indicate that the depth to groundwater ranged from a minimum of 16.5 feet to a maximum of 21.2 feet between January 1990 and November 2004. Again, based on the boring log for well 89-3, unsaturated alluvial material above the water table (vadose zone) beneath the electric shop is composed of a black, sticky clay from ground surface to 7 feet below ground overlying cobbly sand and sandy gravel. The direction of groundwater flow is somewhat uncertain beneath the target treatment area. Based on water level data for well 89-3 and the other closest monitoring wells, the groundwater flow direction appears to be due east. However, on a larger scale, the PCE plume appears to migrate in a more northeasterly direction.

The hydraulic characteristics of the aquifer in the immediate vicinity of the target treatment zone are not specifically documented. However, based on data collected across the Facility, the aquifer is known to be highly transmissive. The conductivity for the aquifer is estimated to range from 170 to 380 feet per day (ft/day). Groundwater flow at the Facility is generally toward the Yellowstone River, with a hydraulic gradient of

about 0.004 feet per foot (ft/ft). The effective porosity was estimated in the ROD at 0.15 to 0.25. Using this range of characteristics, groundwater velocities are estimated to be between 3 and 10 (ft/day). Water levels fluctuate seasonally at the Facility, with an annual range of up to 6 feet in the area of the free product plume.

2.3 GROUNDWATER MONITORING DATA

Historical analytical data obtained during previous investigations/monitoring events that are pertinent to Task F are summarized in Table 2 (VOCs), Table 3 (natural attenuation parameters and general chemistry), and Table 4 (total and dissolved metals and associated analytes) of Stage I – Part 1 RA Plan (DEQ 2007).

The groundwater monitoring data collected from wells at the Facility have been used to assess the distribution and temporal changes in concentrations of chlorinated VOCs in the alluvial aquifer.

Isoconcentration maps based on the concentrations and distributions of chlorinated ethenes (PCE; TCE; and cis-1,2-DCE) for the June and November 2004 data are provided in Appendix B. Maps based on the previous groundwater sampling events are provided in Stage I – Part 1 RA Plan (DEQ 2007).

2.4 RELEVANT INTERIM ACTIONS AND FS WORK

To mitigate potential sources of chlorinated VOCs in groundwater, DEQ and BNSF conducted interim actions, including source removal, as described in the ROD and summarized below. Additional information regarding interim actions is provided in Section 2.4 and Appendix G of the Stage I – Part 1 RA Plan (DEQ 2007). DEQ required that BNSF submit a Comprehensive Interim Action and Confirmation Sampling Summary Report in April 2008. This document is meant to provide detailed information about the interim actions conducted at the Facility and is pending DEQ review.

- Abandoning and Replacing Two City Wells. In 1988, chlorinated VOCs were detected in the Q and L Street municipal wells on the eastern side of the City of Livingston. These wells were decommissioned and replaced with two wells in the southwestern section of the City of Livingston. A new city water line was also installed.
- Replacing Leaking Wastewater Lines and Manways. A project to replace leaking wastewater lines and manways in the Shop Complex began in 1986. In 1988, old sewer lines were slip-lined and some manways replaced. In 1994, four more manways were replaced after hydrostatic testing.
- Removing and Disposing of Wastewater Treatment Plant (WWTP) Sludge. Sludge located in the WWTP sump, cinder pile lagoon, and API separator pond was excavated and placed on temporary liners beginning in 1989. This source control action was taken to reduce potential chlorinated VOC migration from the sludge to groundwater. Sludge within the WWTP grit chambers, the in-line grit chamber, and API overflow pond was also addressed under this action. In 1992, under DEQ direction, approximately 7,000 cubic yards of sludge from these areas was removed, stabilized, and transported to the U.S. Pollution Control, Inc., Grassy/Grayback Mountain Facility in western Utah for disposal (Envirocon 1994).

In 1993, a second phase of sludge removal was conducted at the cinder pile. Approximately 4,700 tons of buried sludge was excavated from the cinder pile, stabilized, and transported to the East Carbon Development Corporation Class II landfill near Price, Utah, for disposal (Envirocon 1994).

- Removing and Disposing of PCE-Containing Soils Underlying the Electric Shop Vapor Degreaser Pit. In 1995, approximately 40 cubic yards of concrete debris, soil, and cobbles were removed from the vapor degreaser pit (DEQ 2001). The soil was shipped to a hazardous waste incinerator in Utah for disposal. In 2000,

an additional 600 cubic yards of soil were removed and treated onsite. In 2005, a portion of this soil was determined to have met ROD-specified cleanup levels and was placed on the cinder pile. The remaining soils have now been determined to have met the ROD-specified cleanup levels and may be disposed of offsite or placed in the C&P Packing rendering pit, following characterization and possible remediation of the soils in the pit. The approximately 6 cubic yards of concrete debris and rocks from the 1995 degreaser pit removal were steam-cleaned and sampled. Chlorinated VOC concentrations in these materials were determined to have met ROD-specified cleanup levels and disposal standards and were disposed of properly offsite at a permitted Subtitle D solid waste facility.

Four soil treatability studies were conducted to investigate methods for remediating soil containing chlorinated VOCs, as follows:

- SVE Treatability Test
- Air Sparging Treatability Test
- Soil Venting Treatability Tests
- Biological Land Treatment Treatability Test.

Tests conducted as part of these studies are described in the *Final Draft Soil and Groundwater Feasibility Study Report* (Envirocon 1998b) and summarized in Section 2.4 of the Stage I – Part 1 RA Plan (DEQ 2007).

3.0 SELECTED REMEDY AND ROD CLEANUP LEVELS

3.1 SELECTED REMEDY

The selected remedy for chlorinated VOCs in groundwater includes source removal of chlorinated VOC-containing sludge and soil followed by MNA. According to the ROD, if the MNA remedy cannot attain the ROD cleanup levels (described below) within a reasonable time as defined by the ROD (20 years), a contingency remedy will be implemented.

3.2 ROD CLEANUP LEVELS

Chlorinated VOC cleanup levels specified in the ROD are shown in Table 1. The ROD cleanup levels for alluvial aquifer groundwater are based on DEQ-7 standards dated September 1999 (DEQ 1999). DEQ has updated the DEQ-7 standards (DEQ 2006), since the ROD was issued in 2001. Table 1 also shows the current (February 2006) DEQ-7 standards for comparison purposes. [Note: The ROD cleanup level for vinyl chloride is 0.15 micrograms per liter ($\mu\text{g/L}$). Since laboratory reporting limits cannot achieve this level, the DEQ-7 standard required reporting limit of 0.5 $\mu\text{g/L}$ will be used for vinyl chloride during RD/RA groundwater monitoring activities.]

The work described in this pilot test work plan will be used to test a selected remedial technology (chemical oxidation using permanganate) to enhance the progress of natural attenuation toward reducing concentrations of chlorinated VOCs in alluvial aquifer groundwater at the Facility to below ROD cleanup levels within a reasonable time as defined in the ROD (20 years). Additional investigations to evaluate the potential stratification of PCE concentrations in alluvial aquifer groundwater in the former vapor degreaser pit will occur under the Stage I – Part 1 RA Plan. The pilot test, described herein, has been conservatively designed using the following assumptions:

- Higher PCE groundwater concentrations than currently detected in samples from well 89-3. Initially an assumption has been made to design the system to treat groundwater containing up to 2,000 µg/L of PCE.
- Presence of PCE throughout the full saturated thickness of the alluvial aquifer in the source area.
- Elevated concentrations of PCE in the unsaturated soil surrounding the former vapor degreaser pit location.
- Actual hydraulic conductivities near the upper end of the values measured at the Facility thereby assuming high groundwater flow velocities.

If approved by DEQ, the system design may be modified from what is proposed in this pilot test work plan depending on the results of the Task F Stage I – Part 1 work plan.

4.0 DESCRIPTION OF PILOT TEST - IN SITU CHEMICAL OXIDATION

This section includes a description of the chemical oxidation technology, available oxidant chemicals and rationale for selection of permanganate as the proposed oxidant at the Facility, oxidation chemistry of permanganate, a typical full scale system design, and considerations that need to be addressed in the implementation of the permanganate oxidation technology.

4.1 TECHNOLOGY DESCRIPTION

In situ chemical oxidation technologies are predominantly used to cleanup VOCs in treatment zones within saturated and unsaturated zones (EPA 1998, 2004; ITRC 2005). This technology is based on the delivery of chemical oxidants to affected groundwater and vadose zone soil in order to oxidize VOCs by converting them to innocuous compounds commonly found in nature (water, carbon dioxide, chloride). Oxidation reactions result in complete destruction of chlorinated VOCs, without the formation of chlorinated VOC by-products (i.e., vinyl chloride).

Commonly applied oxidants include hydrogen peroxide, permanganate, ozone, and persulfate. The relative power of common chemical oxidants and oxygen is listed in Table 2 for comparison relative to chlorine. Ozone, hydrogen peroxide, and persulfate require a catalyst (typically ferric iron or heat) to generate reactive species such as hydroxyl and per-hydroxy radicals to effectively oxidize organic compounds.

After reviewing chemical stability, onsite storage, mixing, ease of handling, health and safety considerations, and other considerations described below, permanganate was proposed as the oxidant to treat VOCs at the Facility. Specific rationale for selection of permanganate is listed below.

- Permanganate is very stable compared with the other reagents. Therefore, it reacts over a prolonged period in the subsurface allowing the oxidant to more effectively permeate soil and contact adsorbed VOCs.
- Permanganate is effective over a wide range of groundwater pH/alkalinity.
- Chemical oxidation using permanganate produces no significant wastes (i.e., VOC off-gas is minimal).
- The slower reaction rates associated with the use of permanganate minimize heat and gas generated by the exothermic oxidant reaction and as a result reduces health and safety concerns.

There are two common forms of permanganate—potassium permanganate (KMnO_4) and sodium permanganate (NaMnO_4). Both are available in a range of purities and have similar chemical reactivity values. Additionally, both are relatively strong oxidizing agents with a unique affinity for oxidizing organic compounds containing carbon-carbon double bonds, aldehyde groups, or hydroxyl groups.

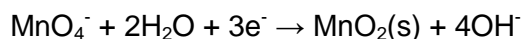
KMnO_4 is a crystalline solid from which aqueous solutions of a desired concentration (up to 4 percent) can be prepared onsite using groundwater or tap water. Because it is a solid, transportation hazards are minimized. NaMnO_4 is usually supplied as a concentrated liquid (40 percent) but is usually diluted onsite and applied at lower concentrations. The potential for higher concentrations of NaMnO_4 solutions gives more flexibility in the design of the injection volume and, because it is in liquid form, the dust hazards associated with dry KMnO_4 solids are eliminated. For these reasons, the liquid NaMnO_4 solution will be used in this pilot study. The specifications for this oxidizer are presented in Section 5.2.

Finally, oxidation of sorbed and non-aqueous phase liquid (NAPL) chlorinated ethenes has been demonstrated with permanganate at various sites. These oxidation reactions occur in the dissolved phase after the chlorinated ethenes desorb from the media and/or

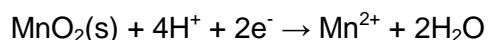
dissolve from the NAPL phase. Poor performance of permanganate is often attributed to injection of an inadequate volume of oxidant to contact the entire target zone, poor uniformity of oxidant delivery caused by low permeability zones and site heterogeneity, excessive oxidant consumption by natural subsurface materials, and/or the presence of large masses of NAPL. These factors will be evaluated through bench- and pilot-scale testing as described in Section 5.0.

4.2 OXIDATION CHEMISTRY OF PERMANGANATE AND IMPLICATIONS

The typical half-cell reaction under common environmental conditions and a typical pH range of 3.5 to 12 is shown below, leading to the formation of a manganese dioxide (MnO_2) solid (ITRC 2005).

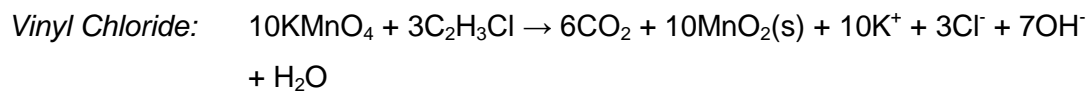
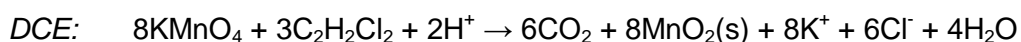
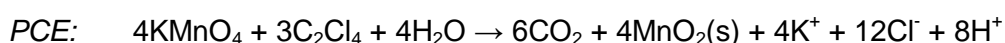


MnO_2 is also naturally reduced slowly to yield reduced manganese ion (Mn^{2+}). This reaction is illustrated below.



The second equation is significant because groundwater acidic conditions may result in a measurable increase in downgradient Mn^{2+} concentrations. The initial subsurface pH, the mass of permanganate reacted, and the subsurface buffering capacity will influence the potential for this effect to occur. Pilot test sampling and analysis will monitor for geochemical changes and mobilization of Mn^{2+} .

Permanganate is a stable oxidant and can persist in the subsurface for months. Thus the application rate and the total mass introduced should be balanced with the subsurface oxidizable material (both natural and from VOCs). For the degradation of chlorinated organic compounds, the oxidation involves direct electron transfer rather than free radical processes that characterize oxidation by persulfate, hydrogen peroxide, or ozone. The stoichiometric reactions of KMnO_4 with the various species of chlorinated ethenes are summarized below (Siegrist et al. 2001):



Based on the above reaction equation, the stoichiometric KMnO_4 requirement for complete PCE mineralization is 0.96 grams of MnO_4^- per gram of PCE, producing 0.7 grams of MnO_2 per gram of PCE. [Note: The literature sources refer to the KMnO_4 reactions and stoichiometric requirements rather than NaMnO_4 . However, the chemical reactions are irrespective of the cation associated with the permanganate ion. The design injection rate of NaMnO_4 is estimated from KMnO_4 chemistry based on the differences in molecular weight between KMnO_4 and NaMnO_4 (Section 5.0).]

The volume, concentration, and number of applications of NaMnO_4 treatments are based on the concentration of chlorinated VOCs to be oxidized; the subsurface volume requiring treatment; and subsurface geochemistry, geology and hydrogeology. The application rate of chemical oxidants increases due to the presence of natural oxidant demand (NOD) since the NOD may consume a much greater fraction of the applied oxidant than the VOCs. The bench-scale testing will provide information to evaluate the required dosage to treat the VOCs present in the source area.

In sites with fine-grained aquifer materials, use of permanganate has resulted in localized reductions in aquifer permeability near the injection point through precipitation of MnO_2 . The subsurface distribution of permanganate has been observed to be fairly uniform in aquifers where conductivity is greater than 10^{-6} feet per second (ft/sec) (or 0.09 ft/day). The hydraulic conductivity for the aquifer was estimated to range from 170 to 380 ft/day. The relatively high hydraulic conductivity of the alluvial aquifer at the Facility does not indicate that the aquifer is susceptible to clogging from MnO_2 precipitation.

Changes in downgradient aquifer water quality may occur from injection and reactions associated with permanganate chemistry (Marvin et al. 2002), as follows:

- NaMnO_4 is derived from mined manganese ores which may contain metal impurities (e.g., arsenic, chromium, lead) that are primary drinking water contaminants, subject to DEQ-7 standards in Montana. Of particular importance, permanganate, and its by-product MnO_2 , can oxidize naturally occurring trivalent chromium (Cr^{3+}) to hexavalent chromium (Cr^{6+}). Technical-grade permanganate stock contains chromium (likely present as Cr^{6+}) as an impurity at part per million levels. Previous field and laboratory results have shown that dissolved Cr^{6+} concentrations often increase after permanganate injection, but that attenuation of the dissolved chromium, by natural reductive and sorptive processes, occurs shortly after the permanganate has been consumed. The bench-scale testing is designed to provide data on concentration and attenuation of the metals of concern.
- Detectable levels of Mn^{2+} may be generated as discussed above. It is expected that with the generally oxygenated nature of the alluvial aquifer groundwater, the reduced Mn^{2+} ions will be oxidized within a short distance downgradient of the reaction point as injected permanganate is mixed with ambient groundwater. The results of the bench-scale test will allow an evaluation of the generation and concentrations of Mn^{2+} .

- Permanganate can temporarily discolor groundwater in the area of injection. The groundwater will exhibit a purple or pink hue until the oxidant has completely reacted. The results of the bench-scale testing will help determine the rate of attenuation of permanganate downgradient of the injection zone.

5.0 PERMANGANATE OXIDATION PILOT TEST PLAN

This section presents the objectives of and procedures for implementing a pilot test to evaluate the feasibility and effectiveness of chemical oxidation using NaMnO_4 as a potential technology for reducing concentrations of chlorinated VOCs in alluvial aquifer groundwater at the Facility. The pilot test will be conducted in the area of the former Electric Shop vapor degreaser pit (treatment area) in the general vicinity of well 89-3.

5.1 OBJECTIVES

The pilot test includes bench-scale treatability and field permanganate injection tests. The specific objectives of the pilot test are to:

- (1) Obtain bench-scale test data to confirm the effectiveness of the NaMnO_4 treatment of VOCs in the treatment area and refine the field test target application rates.
- (2) Conduct a field injection test that provides data/information to evaluate technology performance; design parameters (e.g., injection spacing, volumes, flow rates, and pressures); and the feasibility of full-scale treatment using NaMnO_4 .

5.2 PILOT TEST TECHNICAL APPROACH

The overall approach of the pilot test is to inject a pre-determined amount of NaMnO_4 in the treatment area groundwater and monitor for downgradient changes in groundwater VOC concentrations and other relevant performance parameters (e.g., metals concentrations, permanganate concentrations, injection radius of influence, total dissolved solids, chloride concentrations, sulfate concentrations, alkalinity, and pH).

The NaMnO_4 will be injected into borings using injection probes to create a treatment zone (see Figure 3). The results will be used to design a full-scale system or, if the results are not favorable, they may be useful in evaluating another technology to propose for pilot testing.

The success of the use of NaMnO_4 relies heavily on its ability to come into contact with VOCs in the subsurface. The amount of NaMnO_4 injected must be adequate and the delivery mechanism must be capable of dispersing it throughout the treatment zone. The treatment zone will include the saturated thickness of the alluvial aquifer and extend into the overlying unsaturated zone. Specifically, the full-scale delivery system design should be based on the following data and information, which will be evaluated during the pilot test:

- Site-specific NaMnO_4 mass required to satisfy NOD and treat VOCs
- Potential application delivery rate including mass of NaMnO_4 , mixing ratio with water, and achievable injection rate
- Number and depth of application boreholes
- Injection equipment and method.

Monitoring results will provide the information needed to assess the success of permanganate injection in reducing groundwater VOC levels. Data and information to obtain will include:

- System data on performance of NaMnO_4 delivery system
- Water quality data including changes in concentrations of dissolved VOCs over time, subsurface distribution of NaMnO_4 , and related water quality parameters (see Section 6.2)

- Health and safety issues
- Modifications deemed necessary to refine system operation.

5.3 BENCH-SCALE TREATABILITY TESTING

The objectives of the bench-scale treatability testing are to evaluate the following:

- Site-specific soil oxidant demand (SOD) using Facility groundwater and soil
- Site-specific NaMnO_4 mass required
- VOC treatment efficiency with differing NaMnO_4 dosage rates
- Secondary water quality effects of the permanganate oxidation process including production of MnO_2 precipitate and potential for aquifer clogging, production and attenuation of oxidized metals such as Cr^{6+} , production and attenuation of Mn^{2+} ions, and stability and attenuation of permanganate.

The bench-scale test was conducted by PRIMA Environmental of Sacramento, California (PRIMA) [<http://www.primaenvironmental.com>]. PRIMA's standard operating procedures (SOPs) and information introducing PRIMA and its services are included in Appendix C. As the bench-scale testing progressed, the DEQ was periodically updated with set-up/operation specifics, results, and recommendations (i.e., justify VOC Destruction and Water Quality Testing NaMnO_4 loading rates based on SOD results).

The NaMnO_4 product selected for the pilot test is RemOx[®] L ISCO Reagent as manufactured by Carus Chemical Company (Carus) of Peru, Illinois. The reagent has been specifically manufactured for environmental applications such as remediation of soils and associated groundwater. Based on communication with Carus, RemOx[®] L ISCO Reagent has been used in remedial actions in 46 states that the

company is aware of, primarily for treatment of chlorinated ethenes. A fact sheet and material data safety sheet (MSDS) for the RemOx[®] L ISCO Reagent is provided in Appendix D.

5.3.1 Bench Test Sample Collection

For the SOD portion of the bench-scale test, soil and groundwater samples were collected during installation of the VOC source area monitoring well (07-16) as proposed in Task F Stage I – Part 1 RA Plan (DEQ 2007). New well 07-16 is located cross-gradient of the treatment zone as shown on Figure 3.

For the VOC Destruction, Water Quality Testing, and Chromium Attenuation portion of the bench-scale test, soil was collected from borings 08-SB1 through 08-SB5 and groundwater collected from well 89-3. The soil collected from these borings exhibited similar physical characteristics and SOD results as soil collected from well 07-16. Sample collection procedures are presented below.

5.3.1.1 Soil Samples. Based on review of the boring log for nearby well 89-3, the lithology of the soil beneath the surface fill material in the treatment zone appears to be uniform coarse sand except for a 4-foot layer of coarse gravel encountered at approximately 20 feet bgs. The bench-scale testing SOP requires approximately 6 kilogram (kg) (14 pounds) of soil be collected (Appendix C). This soil was collected from multiple depths within the coarse sand strata in the capillary fringe and the underlying saturated unconsolidated deposits.

A photoionization detector (PID) was used in the field during drilling to screen the drill cuttings and to attempt to collect soil samples that contain the highest VOC concentrations encountered. PID measurements were taken according to the procedures presented in SOG-4A provided in Appendix A of the Facility-Wide SAP (Kennedy/Jenks Consultants 2006). Samples were collected in large liter or gallon glass jars and will be handled, stored, and shipped to PRIMA according to the protocols

presented in SOG-3 of the Facility-Wide SAP. It should be noted that the collected soil samples were handled in the field in a manner to reduce loss of VOCs. However, it was not critical to take extraordinary steps to minimize or eliminate VOC losses since the soil was composited in the laboratory and placed in reaction containers and some VOC loss was expected and acceptable.

Once received by PRIMA, the soil samples were sieved to remove particles larger than #4 mesh size and composited. As mentioned above, this likely resulted in a decrease of VOC concentrations relative to the field; however, this does not impact the ability to meet the objectives of determining SOD, associated NaMnO₄ mass required, the impact of varying NaMnO₄ concentrations on reaction efficiency, and secondary water quality effects. Initial sample analysis was conducted to determine baseline conditions prior to bench-scale testing. The soil analysis included VOCs and priority pollutant metals (antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, and zinc). Soil samples were sent to TestAmerica Laboratories, Inc. of Bothell, Washington (TestAmerica) under chain-of-custody protocol for these analyses. Table 3 summarizes the untreated soil analyses.

5.3.1.2 Groundwater Samples. For the SOD portion of the bench-scale test, fifteen (15) liters of groundwater were collected from monitoring well 07-16. For the VOC Destruction, Water Quality, and Chromium Attenuation portion of the bench-scale test, approximately twelve (12) liters of groundwater were collected from well 89-3. Groundwater was collected from the depth corresponding to the highest detected VOC concentrations following initial sampling, as described in Task F Stage I – Part 1 RA Plan (DEQ 2007).

Groundwater samples were collected using the low-flow purge and sample procedures presented in SOG-8 of the Facility-Wide SAP. A peristaltic pump with the intake position in the middle of the well screen corresponding to the high-VOC concentration depth was used for this purpose. Groundwater samples were collected in 1-liter amber glass

bottles and handled and shipped according to the protocols in SOG-3 of the Facility-Wide SAP.

Once received by PRIMA, the groundwater samples were composited and analyzed for baseline chemical analysis of VOCs, chloride, sulfate, total dissolved solids (TDS), priority pollutant metals, manganese, oxidation-reduction potential (ORP), and pH. Samples were sent to TestAmerica under chain-of-custody protocol for these analyses except ORP and pH, which were to be measured by PRIMA. Table 3 summarizes the untreated groundwater analyses.

5.3.2 Experimental Methods and Procedures

Two sets of experiments were performed to assess (1) site-specific SOD values, and (2) VOC oxidation extent and the secondary water quality effects of permanganate reduction. These tests are described below.

5.3.2.1 SOD Testing. A preliminary test was performed to estimate a site-specific SOD value for the treatment area. The SOD values include both the NOD and the oxidant demand from VOCs. Because the SOD was expected to be relatively low for the Facility media, the preliminary test will be operated at a loading of 0.2 grams NaMnO_4 /kg soil and 2 grams NaMnO_4 /kg soil (Marvin et al. 2002 based on KMnO_4). The NaMnO_4 solution was added to samples of Facility soil and groundwater, mixed in a 1:1 ratio [50 grams of soil and 50 milliliters (mL) of groundwater] in air tight containers. The containers were continuously shaken for 24 hours, after which the mixture was centrifuged, and the supernatant filtered through a 0.45 micron (μm) filter, and then analyzed colorimetrically for permanganate. The results will be used to determine an initial approximate level of appropriate NaMnO_4 loading.

To narrow the range of SOD values from the preliminary test results, three sets of bottles, each set consisting of five 125-mL amber glass bottles and each bottle containing a 1:1 mixture of soil and groundwater and NaMnO_4 solution, were prepared

for further testing. Each set contained a different loading of NaMnO_4 as determined by the preliminary test. The bottles were shaken approximately twice per day. One bottle from each set was destructively sampled and analyzed for residual permanganate after 2 hours, 6 hours, 24 hours, 4 days, and 10 days. The samples were centrifuged and filtered using a 0.45 μm filter prior to permanganate analyses.

5.3.2.2 VOC Oxidation and Water Quality Testing. Batch tests were performed to verify that VOCs present in treatment area groundwater can be oxidized by NaMnO_4 and to determine the effect of NaMnO_4 treatment on selected water quality parameters. Three sets of reaction vessels were prepared, each set consisting of three vessels, and each vessel containing a 1:2 ratio of soil and groundwater (900 grams soil and 1,800 mL of groundwater). Concentrated NaMnO_4 solution was added to two of the sets at amounts to be consumed within about 10 days (based on loading rate determined from the SOD test). The third set served as the control and did not receive NaMnO_4 .

The reaction vessels were capped and placed on a shaker table. Following 1, 4, and 10 days of shaking, one vessel from each set was removed from the shaker table, sampled, and the aqueous phase analyzed for pH, ORP, and residual permanganate by PRIMA, and VOCs, priority pollutant metals, chloride, sulfate, manganese, and TDS by TestAmerica. Aqueous phase sampling is described in Appendix C. Table 3 summarizes the specific analyses that will be performed under each set of experimental conditions at each reaction time.

For VOCs, pH, and ORP, the soil in the vessels was allowed to settle and the aqueous-phase decanted prior to analysis. Samples for VOC analysis were quenched of residual permanganate by adding manganese sulfate to prevent continued oxidation of VOCs. The remainder of the soil/water mix was then centrifuged and filtered using a 0.45 μm filter prior to the remaining analyses. The pH and ORP values were measured by PRIMA and the VOCs will be analyzed by TestAmerica.

5.3.2.3 Formation and Attenuation of Chromium (Total and Hexavalent). If total chromium is formed at concentrations of concern (as determined during the VOC

Oxidation and Water Quality Testing portion of bench-scale study) additional testing may be conducted to determine whether Cr^{6+} can naturally attenuate within the bench-scale testing timeframe in the treatment zone and downgradient of the treatment zone. Both scenarios (i.e., within and downgradient of the treatment zone) were evaluated because soil within the treatment zone may be less able to attenuate Cr^{6+} than soil immediately downgradient of the treatment zone. Tests using treated soil represent conditions within the treatment zone, while tests using untreated soil represent conditions downgradient of the treatment zone.

The available reducing capacity of treated and untreated soil was measured using the methods developed by Bartlett (1991). In these tests, soil was placed in vials containing a 10 millimolar (mM) phosphate buffer solution (Bartlett 1991) that has been spiked with Cr^{6+} then mixed continuously. After 18 hours, the aqueous phase was analyzed for Cr^{6+} . The amount of Cr^{6+} removed per mass of soil is defined in Bartlett (1991) as the available reducing capacity of the soil.

Two additional tests using site soil and treated site groundwater (rather than phosphate solution) were also performed. For the treatment zone test, a series of vials were prepared containing treated soil and treated water (from the VOC Oxidation and Water Quality Testing portion of the bench-scale study). For the downgradient treatment zone test, a series of vials were prepared containing untreated soil and treated water (taken from the VOC Oxidation and Water Quality Testing portion). The vials were shaken by hand approximately twice per day with replicates destructively sampled (i.e., sample vial cannot be reused) on a periodic basis and analyzed for residual Cr^{6+} . It is anticipated the treatment zone test will run between 30 and 60 days. The downgradient treatment zone test will be run for 30 days. A control test (i.e., series of vials prepared with treated water, but no soil) was not performed. The control test was not performed because NaMnO_4 (i.e., treated water contained residual NaMnO_4 at conclusion of VOC Oxidation and Water Quality Test; approximately 11 days) would not be consumed within the time frame of the chromium attenuation study. Therefore, a control test was not appropriate.

For these tests, Cr^{6+} will be analyzed using a Hach DR 2010 Spectrophotometer and appropriate Hach reagents by PRIMA.

5.4 PERMANGANATE INJECTION TESTING

A field NaMnO_4 injection test will be conducted based on the results of the bench-scale test. The NaMnO_4 injection test will be executed in a single event to determine effectiveness, obtain design parameters, and monitor for potential water quality impacts. A full-scale treatment design may then be recommended based on the NaMnO_4 injection test results.

The injection system design and the field implementation plan are described below.

5.4.1 NaMnO_4 Injection System Design Parameters

The design considerations for development of the injection test include field NaMnO_4 mass required for soil and groundwater VOC treatment, downgradient fate and transport of permanganate and soluble metals, MnO_2 precipitation effect on aquifer porosity, and treatment zone metals loading due to natural impurities in NaMnO_4 stock solution. The design considerations are discussed below along with the proposed system layout.

5.4.1.1 Oxidant Mass Calculations. The mass and volume of NaMnO_4 required for treatment will be calculated based on physical dimensions of the target PCE source area and the value of SOD obtained from the bench study. Based on an assumed SOD value of 0.5 gram of NaMnO_4 /kg soil, a target pore volume of 33,660 gallons (see Appendix E), a conservatively-high PCE concentration of 2,000 $\mu\text{g/L}$ in groundwater, a 40 percent NaMnO_4 stock solution, and a radius of influence of 3 feet, approximately 190 gallons of NaMnO_4 stock solution and approximately 3,960 gallons of dilution water are estimated. The injection volume will result in displacement of approximately 12 percent of total “mobile” pore volume. This results in a 2.86 percent NaMnO_4 injection solution concentration. The design parameters will be finalized with the SOD results of the bench test and the PCE concentrations obtained from the new characterization well. Input variables and calculations for the equivalent NaMnO_4 loading are presented in Appendix E.

The preliminary SOD assumption of 0.5 gram of NaMnO_4 /kg soil appears to be reasonable for initial design purposes based on values published in Marvin et al. 2002. SOD values range between 0.5 and 1.5 grams KMnO_4 /kg soil (or 0.45 and 1.35 grams NaMnO_4 /kg soil) for coarse sands and gravels, similar to lithology at the Facility. SOD values are typically reported relative to KMnO_4 and a unit conversion is used to obtain the equivalent SOD as NaMnO_4 (Marvin et al. 2002).

5.4.1.2 Fate and Transport of Permanganate and Soluble Metals. Based on volumetric displacement, advection under ambient groundwater conditions, and the SOD of the aquifer materials, the estimated distance of the leading edge of permanganate mass downgradient of the injection point can be calculated. This calculation will be performed once the SOD for the treatment area is determined either by numerical modeling or analytically using reasonable assumptions of the mass of soil encountered by the oxidant solution along the flow path. The results of this calculation will provide an initial screening as to whether transport of soluble metals downgradient might be a concern.

The time required for Cr^{6+} to attenuate to Cr^{3+} will be estimated during the bench-scale test. No applicable literature values were available to estimate the reduction rates for Cr^{6+} to Cr^{3+} , therefore, a preliminary transport distance has not been estimated. The injection test monitoring results will be used to evaluate site-specific attenuation of Cr^{6+} .

5.4.1.3 Expected Metals Concentrations. The RemOx[®] L ISCO Reagent contains low levels of metals impurities as indicated in the fact sheet in Appendix D. The values presented on the fact sheet were used to determine increased groundwater metals concentrations for comparison to DEQ-7 standards. The effective groundwater metals concentrations are based on the total mass of NaMnO_4 injected, the initial metals concentrations in the treatment area, and the groundwater volume contained beneath the treatment area, assuming a saturated thickness of 20 feet.

The calculated metals concentrations do not exceed DEQ-7 standards, with the exception of thallium and iron, as shown in Table 4. Thallium is shown to exceed the

DEQ-7 standard because the calculation is based on the reporting limit presented in the fact sheet (Appendix D). However, its actual concentration in the reagent may be less than the DEQ-7 standard since the calculations are conservative in that they assume that all of the metals added to the system remain in solution (no complexing or precipitation) and no dispersion or dilution occurs due to groundwater advective flow. The use of NaMnO₄ in the bench study will give an initial indication of what can be expected, and thallium, lead, and iron generation and attenuation will be monitored as part of the post-injection activities. (Note: The background iron concentration exceeds the DEQ-7 groundwater standard based on the federal secondary maximum contaminant level and would not appreciably change due to the iron content of the permanganate product.)

5.4.1.4 System Design Layout. The proposed system is schematically shown on Figure 3. The system includes the following components:

- Injection borings – Four borings will be used to inject NaMnO₄ into the treatment zone as described in Section 5.4.2.
- A non-metallic, air-diaphragm pump will be used to inject the NaMnO₄ solution. The pump body is thermoplastic (e.g., polypropylene) and compatible with NaMnO₄. The pump operates at a maximum flow rate of approximately 50 gallons per minute (gpm) at low pressure and maximum pressure of 120 pounds per square inch (psi) total dead head. Additionally, an electronic metering pump will be used to pump NaMnO₄ stock solution to the mixing tank.
- A lay-flat flexible water discharge hose, rated to 150 maximum working pressure, will be used between borings, pump, and water supply. Compressed air flow will be regulated at the pump inlet to vary the injection flow rate and pressure.
- A 0 to 60 pounds per square inch gauge (psig) and a 0 to 30 gpm in-line flow meter will be located on the discharge side of the pump to monitor for injection pressures and injection flow rate.

- Check valves and a manually-operated pressure relief valve will be used. The pressure relief valve will be on the discharge side of the pump and vented to a return line on the mixing tank in the event of over pressurization of the injection equipment.
- A mixing tank constructed of thermoplastic (e.g., polyethylene) with a capacity of 1,000 gallons will be used. A water supply truck may be employed onsite during the hydraulic testing to supply additional potable water to the mixing tank if an onsite potable source is not readily available. The mixing tank will be double contained to prevent leakage of NaMnO₄.
- The NaMnO₄ stock solution will be stored in 55-gallon lined steel drums, and will be double contained.

5.4.2 NaMnO₄ Injection Field Implementation Plan

This section describes the field implementation tasks for the NaMnO₄ injection test including bromide tracer testing, field kick-off meeting, borehole installation and well completion, and NaMnO₄ dilution and injection.

Bromide Tracer Testing. A tracer test was performed in the former Electric Shop using bromide to verify groundwater flow direction and velocity. Previous studies at the Facility have indicated a seepage velocity of approximately 10 (ft/day). The tracer test was designed to verify the groundwater velocity and also verify possible preferential flow direction.

5.4.2.1 A bromide solution was injected into monitoring well 07-16 and monitored at downgradient wells within the former Electric Shop and monitoring well 08-1 located in the Locomotive Shop (Figure 3). Groundwater was monitored at each well within the

former Electric Shop following injection. Groundwater samples were submitted to Energy Laboratories for bromide analysis using EPA Method 300.

The sampling schedule for the bromide tracer test included baseline analytical testing of all monitoring wells in the Electrical Shop for bromide using EPA Method 300. BNSF injected sodium bromide solution in monitoring well 07-16 at a volume and concentration agreed upon between DEQ and BNSF based on solute transport modeling and upon background bromide concentrations. Groundwater samples for bromide analysis were collected at monitoring wells 07-2A, 07-2B, 89-3, 07-13, 07-14, 07-15, 08-1, and 08-2 (Figure 3). Groundwater samples were collected daily following injection for 14 days.

5.4.2.2 Field Kick-off Meeting. Prior to beginning drilling, Kennedy/Jenks Consultants field supervisor will meet with the drilling subcontractor to discuss logistics and health and safety concerns. Installation of the NaMnO₄ injection borings will be scheduled to begin after the kick-off meeting.

5.4.2.3 New NaMnO₄ Injection Boreholes. Four boreholes (designated IW-01 through IW-04) will be advanced within the treatment area to distribute NaMnO₄ over the 30-foot by 30-foot area as shown on Figure 3. The borehole locations have been selected to achieve significant coverage of the treatment area during injection, while relying on advective transport to treat the most downgradient portion of the treatment zone. Borehole spacing may be adjusted in the field based on observations made during injection at the initial borehole and the locations of underground utilities.

The boreholes will be placed at a distance of at least 10 feet from the former Electric Shop building to avoid concrete pilings installed to support the building foundation. The pilings were installed during the previous soil removal action and extend to approximately 15 feet bgs. The pilings should not act as a barrier to advective flow of NaMnO₄ in the saturated zone downgradient of the treatment zone. At a distance of 10 feet from the boreholes, the pilings should not provide a conduit for short circuiting to the surface due to the high aquifer material hydraulic conductivity.

Injection into each borehole will be completed in stages at short intervals using a “top-down” injection approach. Borehole depth and completion details will be based on the lithologic and physical conditions encountered at the time the boreholes are advanced. The boring logs (included in Appendix F) for existing well 89-3 and well 90-6 provide an initial interpretive stratigraphy at this location. The boreholes will be advanced using direct-push drilling methods to depth of bedrock.

Field personnel will perform borehole logging using the procedures described in SOG-13 (Appendix A of the Facility-Wide SAP). Soil cores will be field screened for presence of VOCs using a PID. Field information will be recorded on appropriate field forms and/or field notebook and provided as a project deliverable.

5.4.2.4 NaMnO₄ Dilution and Injection. The NaMnO₄ stock will be shipped to the Livingston railyard by the supplier Carus in a concentrated solution (approximately 40 percent by weight). The stock solution will be diluted onsite with potable water in an aboveground mixing tank to achieve a 2.86 percent concentration for injection based on the results of bench-scale testing for the site-specific SOD value. An assumed SOD of 0.5 gram NaMnO₄/kg of aquifer material was used to develop approximate concentrations for loading of NaMnO₄ as discussed in Section 5.4.1.1. An estimate based on the assumed SOD value yields a mass of approximately 2,200 pounds of 40 percent NaMnO₄ solution (Appendix E) to be delivered to the treatment zone during the injection event. When diluted to an estimated concentration of 2.5 percent by weight for injection, the total estimated injection volume is approximately 4,150 gallons.

Injection at the initial borehole will be monitored at wells 07-16, 07-2A, 07-2B, 89-3, 07-13, 07-14, 07-15, and 08-2 as described in Section 6.2.2. The following will be evaluated:

- Hydraulic ROI associated with the injection method and equipment being used. The ROI is representative of the radial distance that a chemical oxidant will travel away from an injection boring during the injection process. It is expected that the

injection process will overwhelm the natural groundwater hydraulic regime resulting in an initially relatively circular injection pattern. This initial distribution pattern will be influenced by the local-scale heterogeneities in aquifer permeability. Following injection, NaMnO₄ solution will travel farther downgradient than the ROI with advective groundwater flow.

- Injection flow rates, volumes, and pressures to achieve a given ROI.
- Target pressures, flow rates and volume injected for the selected ROI for each injection depth interval with varying geology between about 15 and 33 feet bgs.
- “Short circuiting” through channeling of injected water to the surface or laterally, thus reducing potential contact between NaMnO₄ and VOCs.

Subsurface NaMnO₄ delivery will be performed using direct-push or sonic drilling techniques. The drill rod will be advanced to the bottom of the uppermost target depth increment, then pulled back to expose the entire target depth increment for injection. The casing will then be advanced to the bottom of the next deepest depth increment and the process repeated. The uppermost depth increment will be comprised of unsaturated and saturated soil, and the lower increments will be in the saturated aquifer material.

Variable rate injection will initially be conducted. This injection will permit evaluation of the ROI at the highest flow rate and associated injection pressure achievable.

Tentatively, the test will be done at two stepped injection rates of 5 and 15 gpm to prevent injection pressures from exceeding 1 psi per foot of overburden. This might result in lower flow rates being used than suggested here.

The hydraulic response in well 89-3 will be quantified by a water column rise of greater than 0.01 foot. The water level change will be measured using an electronic water level meter.

After injection at each interval, water levels will be allowed to return to near static levels or within 0.05 feet of the initial water level measured in well 89-3 prior to initiating injection at the next interval.

Short circuiting may occur through the annulus of injection borings, or other fissures, or away from the treatment zone via existing pipelines, manways, or other subterranean infrastructure, or through zones of aquifer material with higher conductivity and effective porosity. Visual observations will be made during the injection test to determine if short circuiting to the surface occurs.

During testing, field personnel will evaluate both the efficiency and integrity of the above-ground injection equipment for health and safety concerns associated with NaMnO_4 injection. Equipment will be checked for leaks.

Following NaMnO_4 injection, borings will be grouted to the surface with bentonite.

6.0 PILOT TEST SAMPLING AND ANALYSIS PLAN

This task-specific SAP will be used to evaluate the effectiveness of NaMnO_4 oxidation. It will be used in conjunction with the Facility-Wide SAP, which addresses general protocols and procedures to be followed during implementation of RD/RA tasks. The Facility-Wide SAP addresses (1) health and safety considerations (including location of underground utilities); (2) personnel and equipment decontamination; (3) calibration and use of field measuring devices and instrumentation; (4) sample collection, preservation, packaging, and shipping; (5) borehole logging; (6) well construction and development; and (7) handling and disposal of IDW. Field activities will be performed in a manner consistent with the SOGs identified in the Facility-Wide SAP. Field procedures in the Facility-Wide SAP are not repeated in this task-specific SAP unless modifications/additions to a protocol or procedure are proposed.

This task-specific SAP includes injection process monitoring and injection effectiveness monitoring. Additionally, the protocol that will be followed for installation of new monitoring wells are presented.

6.1 INJECTION PROCESS MONITORING PLAN

A Power Probe 9260 drill (direct push) or sonic will be used to inject the NaMnO_4 solution. During borehole advancement, continuous soil samples will be collected using a MACRO type sampler or equivalent, where soil is collected in 5-foot increments in acetate sleeve liners. If the Power Probe hits refusal, soil sampling can be performed using the methods previously used at the Facility. BNSF will submit four soil samples per boring location for laboratory analysis using EPA Method 8260. Tentatively, soil samples will be collected for analysis from: immediately beneath the concrete slab and fill material; 10 feet beneath the slab; and immediately above the water table in the vadose zone, and in the saturated zone where primary treatment is expected to occur. If, during borehole advancement and logging the continuous soil samples, field observations indicate that additional samples may provide important information,

opportunistic samples will be collected and submitted for laboratory analysis. In conjunction with the advancement of the permanganate injection borings (IW-01 through IW-04) that will be installed in the area of the former degreaser pit, continuous soil samples will be collected from one or more of the borings to better characterize the vadose zone in this suspected source area.

Process monitoring includes activities designed to monitor the operation of the NaMnO_4 solution injection equipment such as line pressures and flow rate, and activities designed to monitor the subsurface distribution of the injected NaMnO_4 throughout the treatment zone.

Oxidation-resistant in-line flow meter and pressure gauge will be used to measure and control injection volumes into the depth increments at each borehole. The achieved pressures and flow rate values will be recorded on appropriate field forms and/or notebook.

The line pressure and overall status of the hoses and other components will be monitored regularly as part of the project health and safety activities.

The volume of NaMnO_4 stock solution that will be added to the mixing tank will be determined through monitoring container volume changes. The required water volume will be determined by filling the mixing tank to the required volume using the tank level sight gauge. The estimated target NaMnO_4 solution concentration is 2.5 percent by weight.

6.2 INJECTION EFFECTIVENESS MONITORING PLAN

Effectiveness monitoring activities will be conducted during the injection event to evaluate the distribution or presence of the NaMnO_4 solution. Groundwater monitoring will be conducted prior to and then following the NaMnO_4 injection event to assess chlorinated VOC oxidation and concentrations and distributions of residual

permanganate and soluble metals. A proposed schedule for injection, baseline, and confirmation monitoring events is presented in Table 5.

6.2.1 Monitoring Well Network

The groundwater monitoring well network will consist of existing wells 89-3, 89-9, and L-87-5; the new monitoring wells 07-2A and 07-2B; and six additional new groundwater monitoring wells, designated 07-13, 07-14, 08-2, 07-16 in the treatment zone, 07-15 to the northeast, and 08-1 inside the western wall of the Locomotive Shop. Two of the new wells (07-13 and 07-14) were installed approximately 40 and 140 feet east and downgradient of the treatment zone, respectively, within the former Electric Shop building to monitor the NaMnO₄ injection test and collect effectiveness data. The distances of 40 and 140 feet correspond to estimated travel times of approximately 1 week and 1 month of permanganate from the treatment zone, based on a seepage velocity of 4.6 ft/day. The third and fourth new wells (08-2 and 07-15) are located approximately 140 feet east-northeast and northeast of the treatment zone, respectively, for the same purpose as the first two, and to account for uncertainty in the groundwater flow direction. A fifth new well (08-1) is located approximately 250 feet of the treatment zone to provide distant downgradient data along a east-northeasterly flow path. The sixth new well (07-16) is located within the treatment zone, approximately 5 feet from one of the injection points. This well, combined with wells 07-2A and 07-2B, will help ensure that the desired ROI is achieved during the pilot test, and will provide data to evaluate NaMnO₄ longevity, effectiveness, and secondary effects in and near the injection zone. The locations of the six new wells are shown on Figure 3.

Groundwater monitoring wells 89-9 and L-87-5 are located approximately 370 and 580 feet downgradient of the treatment zone, respectively (Figure 3). These wells will also be used for monitoring.

6.2.2 Injection Monitoring

Injection monitoring activities will evaluate the presence and distribution of the NaMnO_4 solution during the injection event. These activities will consist of water level measurements, ORP measurements, and visual observations at wells 07-16, 07-2A, 07-2B, 89-3, 07-13, 07-14, 07-15, 08-1, 08-2, 89-9 and L-87-5. Indications of the potential presence of the NaMnO_4 solution include a rise in water level elevation followed by an increase in ORP measurements. Visually, NaMnO_4 imparts a slight purple or pink color at approximately 1 milligram per liter (mg/L). Groundwater will be monitored at least hourly starting prior to injection and for at least one sample after the completion of injection for visual evidence of NaMnO_4 (i.e., pink/purple color) and elevated ORP measurements using a handheld probe. ORP will be measured according to the procedures in SOG-5 (Appendix A of Facility-Wide SAP). If direct visual evidence of permanganate is not observed at well 89-3, the injection strategy will be reevaluated and modified as DEQ deems appropriate.

6.2.3 Baseline and Confirmation Groundwater Monitoring

Groundwater monitoring will be conducted prior to and then following the NaMnO_4 injection event to assess chlorinated VOC oxidation and residual permanganate concentration. Groundwater monitoring will also be conducted to evaluate transport of soluble metals sensitive to the oxidation reaction. Prior to NaMnO_4 injections, groundwater samples will be collected from wells 89-3, 89-9, and L-87-3 and the new wells 07-2A, 07-2B, 07-13, 07-14, 07-15, 07-16, 08-1 and 08-2 to establish baseline conditions. Confirmation monitoring will consist of sampling one or more of these wells for one or more of the listed parameters based on the schedule presented in Table 5.

Baseline and confirmation groundwater samples will be analyzed for the following parameters:

- VOCs by EPA Method 8260.

- Permanganate by absorbance at the 528 nanometers (nm) wavelength (spectrophotometric method).
- Dissolved priority pollutant metals, manganese, and iron by EPA Method 6010/7000 series.
- Total alkalinity by EPA Method 310.1. An increase in alkalinity is attributed to chemical oxidation of soil carbonates.
- Chloride and sulfate by EPA Method 300.0. Chloride is produced when VOCs are destroyed by permanganate oxidation or other processes (i.e., increases in chloride concentrations above background conditions indicates destruction of VOCs).
- TDS by EPA Method 160.1. An increase in TDS is a function of the generation of MnO_2 and liberation of cations and anions into groundwater (i.e., ion exchange with soil matrix).

Bench-scale test results will indicate individual soluble metals concentrations that increase due to chemical oxidation. Those metals showing an increase will also be targeted for analyses during baseline and confirmation sampling.

A total of 6 months of sampling is planned. The need for additional sampling events and changes in sampling parameters will be evaluated based on the results of the first 6 months.

In addition to groundwater monitoring, confirmation soil sampling may be performed to determine whether injection has a beneficial impact on contaminant concentrations in the unsaturated soil within the target treatment zone. Confirmation soil samples (within close proximity to the water table and within the saturated zone where primary treatment is expected to occur) will be conducted only if baseline samples exceed the ROD-

specified cleanup levels. The baseline samples refer to soil sample collection as described in Section 6.1 (i.e., soil samples collected immediately above the water table and within the saturated zone). If VOCs are found above ROD-specified cleanup levels in the baseline samples, then two confirmation borings will be drilled at the end of the pilot study as close as practicable to the baseline borings, and will be sampled in the same manner.

6.3 NEW GROUNDWATER MONITORING WELL CONSTRUCTION

New groundwater monitoring wells 07-13, 07-14, 07-15, 07-16, 08-1 and 08-2 were constructed prior to implementation of the injection test. [Note: New groundwater monitoring wells 07-2A and 07-2B were also constructed prior to implementation of the injection test. These wells were constructed as part of the Stage I – Part 1 RA Plan (DEQ 2007).] The new wells were designated with well identification numbers as outlined in Section B2.3.3 of the Facility-Wide QAPP (presented in Appendix A of the Facility-Wide SAP).

Borings for new groundwater monitoring wells were drilled using sonic drilling, or other suitable drilling techniques based on field conditions and equipment availability. Field personnel performed borehole logging using the procedures described in SOG-13 (Appendix A of Facility-Wide SAP). General procedures followed for well construction are described in SOG-14 and SOG-15 (Appendix A of Facility-Wide SAP). Data collected during borehole advancement and well construction (e.g., soil conditions, depth to groundwater, etc.) and the specific well construction details were documented on appropriate field forms (i.e., boring/well construction log).

Screened intervals were determined in the field based on the subsurface conditions encountered. Generally, the screened intervals were selected based on the thickness of saturated alluvium encountered; the saturated thickness of alluvium in proximity to the pilot test area was approximately 15 feet.

Following construction, the new monitoring wells were developed as appropriate by surging and over-pumping and/or hand-bailing to remove fine-grained particles that entered the well and filter pack during construction. Well development was typically performed until the groundwater was relatively sediment free. General well development procedures followed are identified in SOG-15 (Appendix A of Facility-Wide SAP).

A Montana State registered land surveyor surveyed the new wellheads to determine the vertical elevations with respect to the North American Vertical Datum 1988 (NAVD 88). Well logs will be filed with the Montana Bureau of Mines and Geology.

6.4 GROUNDWATER WELL SAMPLING AND ANALYSIS

Additional information regarding sampling and analyses of monitoring wells for the pilot test is provided below.

6.4.1 Well Access

Access procedures described in Section 2.0 of the Facility-Wide SAP will be followed during pilot test groundwater monitoring sampling events.

6.4.2 Well Purging and Groundwater Sample Collection Procedures

Pilot test groundwater monitoring wells will be purged and sampled using the low-flow purge and sample collection procedures described in Section 5.1.3.1 of the Facility-Wide SAP. The low-flow purging and sampling procedures will be in general accordance with DEQ's *Site Response Section (SRS) Low-Flow Purging and Sampling Guidelines Memorandum* (DEQ 2005a) and Kennedy/Jenks Consultants' letters dated 1 February 2005 (Kennedy/Jenks Consultants 2005b) and 1 June 2005 (Kennedy/Jenks Consultants 2005c) [prepared in response to DEQ's letter dated 20 May 2005]

(DEQ 2005b)]. The low-flow groundwater sampling procedures that will be followed are presented in SOG-8 (Appendix A of Facility-Wide SAP).

Measurements of water quality parameters, including temperature, pH, dissolved oxygen, ORP, specific conductance, and turbidity will be recorded during groundwater purging. An example groundwater purge and sample form is included in Appendix E of the Facility-Wide SAP. After purging the well (unless otherwise stated) and indicator parameter measurements have stabilized, the groundwater samples will be collected from the submersible, bladder, or peristaltic pump discharge line. Sample collection information will be recorded on the groundwater purge and sample form. Additional information regarding groundwater sample collection procedures is provided in SOG-8 (Appendix A of Facility-Wide SAP).

6.4.3 Quality Assurance/Quality Control (QA/QC)

QC samples will be obtained during pilot test groundwater monitoring events as discussed below.

- Duplicates: Duplicate samples will be collected as follows:

No. of Samples Collected per Sampling Event	No. of Duplicate Samples
Less than 5	None
5 – 15	1
16 – 25	2
26 – 35 (and so on)	3 (and so on)

- One trip blank sample will be included with each cooler of samples transported to the analytical laboratory for VOC analysis.

- When non-disposable sampling equipment is used, each field sampling crew will prepare a daily equipment blank sample.
- One field blank will be collected daily; however, if equipment blank sample(s) are prepared, no field blank sample will be necessary. The equipment blank sample will also serve as the field blank sample.

Field and laboratory QA/QC procedures are discussed further in Section B2.5 of the Facility-Wide QAPP (Appendix B of Facility-Wide SAP). In obtaining QC samples, these procedures will be followed.

6.4.4 Split Samples

DEQ may elect to collect split samples to verify analytical results. DEQ will be notified at least 10 days prior to sampling activities to allow collection of split samples.

6.4.5 Sample Labeling

Groundwater samples will be labeled in accordance with Section B2.3.3 of the Facility-Wide QAPP. Groundwater sample identifications will correspond to the well number (e.g., 0Z-2A, etc.). QC samples will be labeled as described in Section B2.3.3 of the Facility-Wide QAPP.

6.4.6 Chain-of-Custody Procedures

Chain-of-custody procedures are discussed in Section B2.3.2 of the Facility-Wide QAPP. Those procedures will be followed.

6.4.7 Sample Shipping and Handling

Sample shipping and handling procedures are discussed in Section B2.3.4 of the Facility-Wide QAPP and SOG-3 provided in Appendix A of the Facility-Wide SAP. Those procedures will be followed.

6.4.8 Sample Analyses

Appropriate sample containers, preservation methods, holding times, and target method reporting limits for the analyses cited in Tables 3 and 5 are provided in Table 6.

The names, addresses, and contacts for the analytical laboratory(ies) to be used for groundwater sample analyses are provided in Section A3 of the Facility-Wide QAPP.

7.0 DATA ANALYSIS AND EVALUATION

The data and information obtained from the pilot test will be reviewed to address the objectives. The following results from the bench-scale test will be reviewed to adjust the permanganate dosage and total volume needed for effective oxidation of VOCs:

- Estimates of the SOD and NaMnO_4 consumption rates.
- Estimates of VOC removal efficiencies in response to increased NaMnO_4 dosages.
- Water quality testing parameter data.
- Soluble metal mobilization and attenuation data.
- Estimates of the mass of Cr^{6+} reduced and potential downgradient treatment.
- Estimates of the potential effect on aquifer permeability as a result of colloidal MnO_2 production.

The results of the NaMnO_4 injection test will be used to evaluate efficacy of this technology to reduce concentrations of VOCs in alluvial aquifer groundwater and unsaturated soils based on:

- NaMnO_4 loading and injection solution volume requirements.
- Groundwater laboratory analytical data over time for VOCs, metals, and other water quality parameters listed previously.

- Unsaturated and saturated zone soil VOC concentrations before and potentially after injections.
- Well water level and field parameter results.

8.0 DELIVERABLES

After a minimum of 6 months monitoring and the receipt of pilot test data to permit evaluation of this technology, BNSF will submit a Stage I – Part 2 Pilot Test report that will include the following elements:

- Description of the work performed.
- Narrative of unforeseen problems and deviations from the pilot test work plan or task-specific SAP.
- Description of general field observations, including soil conditions and characteristics, and field screening and/or visual observations.
- Summary of sampling information, including discussions of methods and equipment used, sample locations and sample identification numbers, sample media and objectives, QA/QC samples, field screening methods, chain-of-custody procedures, and shipping and handling procedures.
- Discussion of analytical parameters, including confirmation that method reporting limits met ROD cleanup levels for chlorinated VOCs; sample containers, preservation, and holding times; and analytical test method used.
- Description of DEQ split sample collection, if any, and analytical results [included in the sample summary table(s)].
- Description of QA/QC sampling procedures, including calibration of field screening equipment.
- Description of decontamination procedures used.

- A statement regarding compliance with ERCLs.
- Summary tables of analytical results (including method reporting limits) compared to ROD cleanup levels for chlorinated VOCs.
- Discussion of analytical results and data evaluation in time and space pertinent to the goals of the pilot test.
- Discussion of QA and data validation, including data validation results.
- Maps identifying sample locations, sample numbers, and chlorinated VOC concentrations, if present.
- A description of the equipment and injection procedures used during the pilot test.
- Tables summarizing injection intervals, volumes, rates, and pressures for completed injection points.
- Feasibility of the implemented drilling and injection delivery system for future application of NaMnO_4 .
- Modifications (if any) to the drilling and injection techniques that were used to enhance NaMnO_4 delivery and to address any potential health and safety issues.
- Conclusions and recommendations for (and justification of) additional sampling, if necessary.
- Appendices with supporting information (i.e., field forms, photographs, laboratory analytical reports, etc.)

Information will also be provided to DEQ in letter proposals, quarterly status and/or annual monitoring and maintenance reports, in accordance with the Spring 2005 SOW requirements.

9.0 PROJECT AND DATA MANAGEMENT

9.1 PROJECT MANAGEMENT

Section B1.0 A: Project Management of the Facility-Wide QAPP describes the project management, including project history and objectives as well as roles and responsibilities of the project personnel involved in RD/RA activities at the Facility. The Facility-Wide QAPP is presented in Appendix B of the Facility-Wide SAP (Kennedy/Jenks Consultants 2006). A project organization chart showing the Task Manager for this pilot test work plan is provided as Figure 5.

9.2 DATA MANAGEMENT

Both field and laboratory data generated during the implementation of the pilot test will be managed as described in the Facility-Wide QAPP. In addition, data generated during the pilot test will be reviewed, verified, and validated as outlined in Section B4.0 of the Facility-Wide QAPP. Data from the pilot test will be evaluated as discussed in Section 7.0 of this work plan.

9.3 ACCESS/SECURITY

The pilot test will be conducted in the area of the Electric Shop on the former Talgo-Livingston Rebuild Center (LRC) property currently owned by MRL (see Figure 3). Access to the property will be in accordance with the notifications procedures identified in the Facility-Wide SAP (Kennedy/Jenks Consultants 2006) and the Facility-Wide Health and Safety Plan (HASP) (Kennedy/Jenks Consultants 2008), and proper identification will be carried at all times while working on the property. Work zones will be established during the step up of the pilot test (e.g., construction of wells, outfitting of injection borings with injection equipment, advancement of soil borings, and others).

When not in use, the permanganate borings and aboveground system components will be either housed in the former Electric Shop building or a temporary structure will be erected around them. The housing unit (either the Electric Shop or the temporary structure) will be locked.

9.4 CONTINGENCY PROCEDURES

In the event of an emergency, procedures identified in the Facility-Wide HASP will be followed.

9.5 COMMUNITY RELATIONS

DEQ will manage community relations, and BNSF will provide community relations support to DEQ, at DEQ's request. DEQ will manage community relations in accordance with the Community Involvement Plan, dated 1991 with amendments and updates.

9.6 MISCELLANEOUS

As the pilot test will be conducted on the former Talgo-LRC property currently owned by MRL, additional measures other than those outlined in the Facility-Wide HASP and task-specific HASP (see Section 11.0), will not likely be required. The pilot test will generate minimal traffic and not result in excess noise that could affect the community.

10.0 IDW MANAGEMENT

The IDW that will be generated during implementation of the pilot test are listed below.

- IDW generated during monitoring well construction and the NaMnO_4 injection test will include soil cuttings, construction/development water, decontamination water, purge water, and non-indigenous IDW [i.e., disposable personal protective equipment (PPE), disposable sample equipment].
- IDW generated during groundwater monitoring will include decontamination water, purge water, and non-indigenous IDW.

As the pilot test is being conducted in an area containing F-listed constituents, construction/development water, purge water, soil cuttings, and decontamination water generated during the pilot test will be reasonably expected to contain F-listed constituents. These IDW will be managed as a hazardous waste, unless determined by DEQ through analytical testing to be non-hazardous, as outlined in Section 8.4 of the Facility-Wide SAP. Non-indigenous IDW will be handled as a non-hazardous waste in accordance with Section 8.4.3 of the Facility-Wide SAP unless the materials are saturated with solvent-containing groundwater or solvent-containing decontamination water, or materials are coated with solvent-containing soil or residue that cannot be removed. In that case, the non-indigenous IDW will be managed as hazardous waste in accordance with Section 8.4 of the Facility-Wide SAP.

11.0 HEALTH AND SAFETY PLAN

The task-specific HASP presented in Appendix G has been prepared in accordance with applicable health and safety regulations. The task-specific HASP is designed for use in conjunction with the Facility-Wide HASP (Kennedy/Jenks Consultants 2008).

Subcontractors to Kennedy/Jenks Consultants will assess work area conditions independently and develop health and safety work practices at least as stringent as those contained in the Facility-Wide HASP and the task-specific HASP. Subcontractors will be required to prepare and submit a HASP to Kennedy/Jenks Consultants prior to implementation of the pilot test. In addition, subcontractors will be required to adhere to all BNSF and MRL safety requirements.

Permanganate is an oxidizer that requires specific health and safety protection measures for storage, handling, mixing, and application. NaMnO_4 has a relatively high solubility and may cause severe burns upon dermal contact. Safety precautions include the use of skin protection and safety glasses during handling and application. Since the permanganate solution is not volatile, inhalation could only occur if the chemical was handled in a manner that would create airborne mist or dust. Workers will handle the chemical in a manner that minimizes the creation of mist. Proper respiratory, eye, face, and skin protection will be worn when working directly with the stock solution. Once NaMnO_4 is placed into solution or injected into the subsurface, exposure to it is very unlikely. Therefore, potential exposure to permanganate is primarily limited to those individuals working directly with the chemical.

12.0 PERMITS

The City of Livingston requires permits to construct groundwater monitoring wells. This permit will be obtained prior to well construction activities. As part of the permitting process, the City of Livingston Building Inspector will be contacted to inspect well construction activities. Contact details are as follows:

Contact: Cynthia Holweger, Building Inspector
(406)-222-1142

The Denver office of the EPA Region 8 was contacted regarding any requirement to obtain a Underground Injection Control (UIC) permit for the injection borings during the pilot test. Information supplied by Ms. Wendy Cheung (303-312-6242) indicates that the NaMnO_4 injection will fall under the Class V UIC Program. BNSF will complete an Inventory Request Form and a Site Information Request Fact Sheet for Aquifer Remediation Injection System/Wells concurrently with DEQ review of this work plan. It appears that the pilot test may be rule-authorized (i.e., a permit will not be required). However, if a permit is deemed to be necessary, it will be applied for immediately.

DEQ determined that the pilot testing of NaMnO_4 injection does not require a Montana Groundwater Pollution Control System (MGWPCS) permit under ARM 17.30.1023, because the pilot test is being performed under the Spring 2005 SOW. All substantive requirements of these regulations will be met.

13.0 IMPLEMENTATION SCHEDULE

A preliminary schedule for implementing the pilot test is shown on Figure 6. DEQ has previously approved the Task F Stage I – Part 1 RA Plan. Initiation of work under the pilot test work will require DEQ approval of this pilot test work plan (Task F Stage I – Part 2 RA Plan). The new wells have been installed in conjunction with other field activities.

Schedule start dates depend upon DEQ approval of the Task F Stage I - Part 2 RA Plan. Task F activities will commence within 30 days of DEQ approval. The schedule is subject to contractor availability (i.e., drilling contractors, PRIMA, etc.), weather conditions, and any other unforeseen field conditions that could affect completion of work in accordance with this preliminary schedule. DEQ will be notified of potential schedule delays.

14.0 ENVIRONMENTAL REQUIREMENTS, CRITERIA, AND LIMITATIONS

ERCLs developed by DEQ for the Facility are included in Appendix A of the ROD. An evaluation of how the activities conducted during implementation of the pilot test will comply with ERCLs is included in Appendix H of this pilot test work plan. Planned activities identified in this pilot test work plan comply with ERCLs.

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TABLE 1

**ROD CLEANUP LEVELS FOR ALLUVIAL AQUIFER GROUNDWATER
Burlington Northern Livingston Shop Complex**

Chemical of Concern	ROD Cleanup Level for VOCs in Groundwater (µg/L)^(a)	Current Circular DEQ-7 Standard for VOCs in Groundwater (µg/L)^(b)
Tetrachloroethene	5.0	5.0
Trichloroethene	5.0	5.0
Cis-1,2-Dichloroethene	70	70
Vinyl Chloride	0.15 ^(c)	0.2
Chlorobenzene	100	100
1,4-Dichlorobenzene	75	75
<u>Trans-1,2-dichloroethene</u>	<u>---</u>	<u>100</u>

Notes:

- (a) *Record of Decision* (ROD) (DEQ 2001) cleanup levels based on *Circular WQB-7, Montana Numeric Water Quality Standards*, September 1999 (DEQ 1999).
- (b) Current groundwater standards based on *Circular DEQ-7, Montana Numeric Water Quality Standards*, February 2006 (DEQ 2006).
- (c) The required reporting limit of 0.5 micrograms per liter (µg/L) will be used for vinyl chloride during remedial design/remedial action (RD/RA) groundwater monitoring activities.

TABLE 2

**RELATIVE POWER OF COMMON CHEMICAL OXIDANTS AND OXYGEN
Burlington Northern Livingston Shop Complex**

Oxidant	Oxidation Potential (volts)	Relative Oxidizing Power (Cl₂=1.0)
Hydroxyl radical (Fenton's Reagent)	2.8	2.1
Sulfate radical	2.6	1.9
Ozone	2.1	1.5
Hydrogen peroxide	1.8	1.3
Permanganate	1.7	1.2
Chlorine	1.4	1.0
Oxygen	1.2	0.9

TABLE 3

BENCH-SCALE VOC OXIDATION AND WATER QUALITY TEST DESIGN
Burlington Northern Livingston Shop Complex

Analyte	Method	Soil (Untreated)	Groundwater Untreated	Control			Low NaMnO ₄			High NaMnO ₄		
				1 day	4 days	10 days	1 day	4 days	10 days	1 day	4 days	10 days
Permanganate	Colorimetric ^(a)	--	--	n.a.	n.a.	n.a.	x	x	<u>x</u>	x	x	<u>x</u>
Volatile organic compounds	EPA 8260 ^(b)	x	x	x	x	x	x	x	x	x	x	x
Priority pollutant metals ^(c,d)	EPA 6020/7000	x	x	x	x	x	x	x	x	x	x	x
Manganese ^(d)	EPA 6020	--	x	x	x	x	x	x	x	x	x	x
Total dissolved solids	EPA 160.1	--	x	x	x	x	x	x	x	x	x	x
Chloride and sulfate	EPA 300.0	--	x	x	x	x	x	x	x	x	x	x
pH	PRIMA	--	x	x	x	x	x	x	x	x	x	x
Oxidation-reduction potential	PRIMA	--	x	x	x	x	x	x	x	x	x	x

Notes:

- (a) Permanganate will be measured colorimetrically (absorbance of 560 nm light). The samples will be centrifuged and filtered through a 0.45 µm filter prior to analyses.
- (b) Manganese sulfate will be added to quench residual permanganate prior to volatile organic compound analysis.
- (c) Priority pollutant metals include: antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc.
- (d) Groundwater samples will be analyzed for total and dissolved metals. The filtered samples will be centrifuged and filtered through a 0.45 µm filter prior to analyses.

nm – nanometer

µm – micron

n.a. – not analyzed

TABLE 4

**TRACE METAL CONTENT AND SPECIFICATION
Burlington Northern Livingston Shop Complex**

Metal	Product Metal Impurity Concentration^(a) (mg/kg)	Product Metal Impurity Mass^(b) (mg)	Product Metal Impurity Pore Volume Concentration^(c) (mg/L)	Maximum Total Metal Concentration^(d) (mg/L)	Total Metal Concentration^(e) (mg/L)	DEQ-7 Standard^(f) (mg/L)
Silver (Ag)	0.04	40	0.0003	<0.005 ^(g)	0.0053	0.1
Aluminum (Al)	0.74	740	0.0058	1.0	1.01	-- ^(h)
Arsenic (As)	0.01	10	0.0001	<0.005	0.0051	0.01
Barium (Ba)	2.16	2,160	0.0170	<0.1	0.12	2
Beryllium (Be)	< 0.08	80	0.0006	NA ⁽ⁱ⁾	0.0006	0.004
Cadmium (Cd)	0.02	20	0.0002	0.001	0.0012	0.005
Chromium (Cr)	1.54	1,540	0.0121	<0.02	0.032	0.1
Copper (Cu)	< 0.022	22	0.0002	NA	0.0002	1.3
Iron (Fe)	0.05	50	0.0004	1.28	1.28	0.3 ^(j)
Mercury (Hg)	< 0.003	3	0.00002	0.001	0.0010	0.002
Nickel (Ni)	< 0.030	30	0.0002	NA	0.0002	0.1
Lead (Pb)	< 0.16	160	0.0013	0.01	0.011	0.015
Antimony (Sb)	< 0.16	160	0.0013	NA	0.0013	0.006
Selenium (Se)	0.006	6	0.0000	<0.005	0.0050	0.05
Thallium (Tl)	< 0.8	800	0.0063	NA	0.006	0.002
Zinc (Zn)	0.026	26	0.0002	NA	0.0002	2

Notes:

- (a) Concentration based on data supplied by Carcus Chemical Company (see Appendix D). The detected metal concentration or the detection limit was used in the product metal impurity mass calculation.
- (b) The product metal impurity mass = product metal impurity concentration x total mass of sodium permanganate (where the total mass of sodium permanganate = 2,200 lbs = 1,000 kg).
- (c) The product metal impurity pore volume concentration = product metal impurity mass/designated treatment area pore volume (where the designated treatment area pore volume = 30 feet x 30 feet x 20 feet x 0.25 x 7.48 gallons/feet³ = 33,660 gallons or 127,403 liters).
- (d) Based on the maximum historical groundwater total metal concentration reported at the Facility.
- (e) Total metal concentration = maximum total metal concentration + product metal impurity pore volume concentration.
- (f) Circular DEQ-7, Montana Numeric Water Quality Standards for Human Health, Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, dated February 2006.

**TRACE METAL CONTENT AND SPECIFICATION
Burlington Northern Livingston Shop Complex**

- (g) "<" denotes analyte not detected at the indicated reporting limit.
- (h) "--" = indicates that a DEQ-7 standard is not available.
- (i) "NA" = Background metal concentration not available.
- (j) The concentration for iron must not reach values that interfere with uses specified in the surface and groundwater standards (Administrative Rules of Montana 17.30.601 and .1001). The EPA secondary maximum contaminant level of 0.3 mg/L may be considered as a guideline to determine the levels that will interfere with the specified uses.

kg - kilogram

lbs - pounds

mg/kg - milligrams per kilogram

mg/L - milligrams per liter

TABLE 5

GROUNDWATER SAMPLING SCHEDULE^(a)
Burlington Northern Livingston Shop Complex

Analyte	Method	Within Treatment Area, including well 07-16	Sample Location (Approximate Downgradient Distance from Treatability Study Area in feet)								
			07-2A/2B (8 feet)	07-13 (40 feet)	89-3 (65 feet)	07-15 (140 feet, northeast) ^(b)	07-14 (140 feet) ^(b)	08-2 (140 feet) ^(b)	08-1 (250 feet) ^(b)	89-9 (370 feet) ^(b)	L-87-5 (580 feet) ^(b)
Volatile organic compounds	EPA 8260	B, W1, M1, M3, and M6	B, W1, M1, M3, and M6	B, W1, M1, M3, and M6	B, W1, M1, M3, and M6	B, M1, M3, and M6	B, M1, M3, and M6	B, M1, M3, and M6	B, M1, M3, and M6	B, M3, and M6	B, M3, and M6
Permanganate	Colorimetric	W1, W2, W3, W4 then biweekly until not detected	W1, W2, W3, W4 then biweekly until not detected	W1, W2, W3, W4 then biweekly until not detected	W1, W2, W3, W4 then biweekly until not detected	W3, W4, then biweekly until not detected	W3, W4, then biweekly until not detected	W3, W4, then biweekly until not detected	W3, W4, then biweekly until not detected	-- ^(c)	--
Dissolved priority pollutant metals ^(d)	EPA 6020/7000	B, W1, M1, M3, and M6	B, W1, M1 through M4	B and M1 through M6	B and M2 through M6	B and M2 through M6	B and M2 through M6	B and M2 through M6	B and M2 through M6	B and M2 through M6	B and M4 through M6
Dissolved manganese	EPA 6020	B, W1, M1, M3, and M6	B, W1, M1	B and M1 through M6	B and M2 through M6	B and M2 through M6	B and M2 through M6	B and M2 through M6	B and M2 through M6	B and M2 through M6	B and M4 through M6
Dissolved iron	EPA 6020	B, W1, M1, M3, and M6	B, W1, M1	B and M1 through M6	B and M2 through M6	B and M2 through M6	B and M2 through M6	B and M2 through M6	B and M2 through M6	B and M2 through M6	B and M4 through M6
Total dissolved solids	EPA 160.1	B, W1, M1, M3, and M6	B, W1, M1	--	--	--	--	--	--	--	--
Chloride and sulfate	EPA 300.0	B, W1, W2, W3, W4, M1, M3, and M6	B, W1, W2, W3, W4, M1, M3, and M6	B, W1, W2, W3, W4, M1, M3, and M6	B, W1, W2, W3, W4, M1, M3, and M6	--	--	--	--	--	--
Total alkalinity	EPA 310.1 or SM ^(e) 2320B	B, W1, M1, M3, and M6	B, W1, M1	--	--	--	--	--	--	--	--
pH	Field	B, W1, W2, W3, W4 then biweekly until falls within 0.5 units of baseline	B, W1, W2, W3, W4 then biweekly until falls within 0.5 units of baseline	B, W1, W2, W3, W4 then biweekly until falls within 0.5 units of baseline	B, W1, W2, W3, W4 then biweekly until falls within 0.5 units of baseline	B and M2 – M6	B and M2 – M6	B and M2 – M6	B and M2 – M6	B and M2 – M6	B and M4 through M6

GROUNDWATER SAMPLING SCHEDULE^(a)
Burlington Northern Livingston Shop Complex

Notes:

- (a) Scheduled frequencies for sampling events:
B = Baseline; W1, W2, etc. = Week 1, Week 2, etc. following injection; M1, M2, etc. = Month 1, Month 2, etc. following injection.
Selection of sampling frequency is based on the following:
 - 1. Assumes sodium permanganate will be consumed within one month of injections.
 - 2. Assumes metal mobilization and migration at groundwater seepage velocity of 4.6 feet per day (neglecting natural attenuation).
- (b) Travel times to these six wells (seepage velocity of 4.6 ft/day) are 3 weeks or greater. Permanganate analysis will be limited in 07-14 and is not proposed in 89-9 or L-87-5 since permanganate is expected to be consumed within a month. Similarly, VOC samples will not be collected until a month after injection. VOC concentrations at later times will be of interest to determine if concentrations decrease as a result of upgradient source degradation. Metals concentrations will be analyzed if the bench-scale test indicates, as determined by DEQ, that attenuation of soluble metals will extend beyond a period of 2 months.
- (c) “—” = indicates that the analysis will not be performed.
- (d) Priority pollutant metals include: antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc. All metals will be analyzed during the baseline and week 1 sampling. DEQ will evaluate the results of the bench test study to determine if the list of priority pollutant metals may be reduced.
- (e) SM = Standard Method.

TABLE 6

**SAMPLE ANALYSES, MATRICES, METHOD NUMBERS, CONTAINERS,
PRESERVATION METHODS, HOLDING TIMES, AND APPROXIMATE REPORTING LIMITS
Burlington Northern Livingston Shop Complex**

Analysis	Matrix	Method Referenced ^(a)	Containers ^(b)	Preservation	Holding Time	Approximate Reporting Limit ^(c)	
						Soil (mg/kg)	Water (µg/L)
Volatile organic compounds	▪ Water	▪ EPA 8260	▪ Two 40-ml vials	▪ HCl ^(d) to pH<2 and refrigerate 4°C	▪ 14 days	0.02 - 0.20	0.50 - 10
	▪ Soil	▪ EPA 8260	▪ 2-oz glass jar	▪ Refrigerate 4°C	▪ 14 days		
Metals	▪ Water		▪ 500-ml plastic or glass container	▪ HNO ₃ ^(e) to pH<2 and refrigerate 4°C			
Iron	▪ Soil	EPA 6020	▪ 4-oz glass jar	▪ Refrigerate 4°C	6 months	5	150
Manganese		EPA 6020			6 months	5	10
Antimony		EPA 6020			6 months	1.5	3
Arsenic		EPA 6020			6 months	0.5	1
Beryllium		EPA 6020			6 months	0.5	1
Cadmium		EPA 6020			6 months	0.5	1
Chromium		EPA 6020			6 months	0.5	1
Copper		EPA 6020			6 months	0.5	1
Lead		EPA 6020			6 months	0.5	1
Mercury		EPA 7471A/7470A			28 days	0.1	0.2
Nickel		EPA 6020			6 months	0.5	1
Selenium		EPA 6020			6 months	0.5	1
Silver		EPA 6020			6 months	0.5	1
Thallium		EPA 6020			6 months	0.5	1
Zinc		EPA 6020			6 months	5	10
Water Quality Parameters	▪ Water						
Total dissolved solids		EPA 160.1	500-ml plastic container	Refrigerate 4°C	7 days	NA ^(f)	10 mg/L
Chloride		EPA 300.0	500-ml plastic container	Refrigerate 4°C	28 days	NA	1.0 mg/L
Sulfate		EPA 300.0	500-ml plastic container	Refrigerate 4°C	28 days	NA	1.0 mg/L
Total alkalinity		EPA 310.1 or SM ^(g) 2320B	500-ml plastic container	Refrigerate 4°C	14 days	NA	5.0 mg/L
Permanganate	▪ Water	Colorimetric	500-ml plastic container	Refrigerate 4°C	Immediately	NA	5.0 mg/L

**SAMPLE ANALYSES, MATRICES, METHOD NUMBERS, CONTAINERS,
PRESERVATION METHODS, HOLDING TIMES, AND APPROXIMATE REPORTING LIMITS
Burlington Northern Livingston Shop Complex**

Notes:

- (a) Methods are referenced in the following documents: *Test Methods for Evaluating Solid Waste, SW-846* (EPA 1986); *Methods for Chemical Analysis of Water and Wastes* (EPA 1983); *Standard Methods for the Examination of Water and Wastewater, 20th Edition* (American Public Health Association et al. 1999).
- (b) More than one analysis may be performed per container (e.g. total dissolved solids and alkalinity). For water quality parameters, a smaller sample container (e.g., 25-ml container) may be provided as determined by the laboratory. Also, additional containers will be collected for laboratory quality control analyses where warranted.
- (c) Reporting limits are matrix and analyte-specific and may be higher due to analytical interferences.
- (d) HCl = Hydrochloric acid.
- (e) HNO₃ = Nitric acid.
- (f) NA = Not Applicable.
- (g) SM = Standard Method.

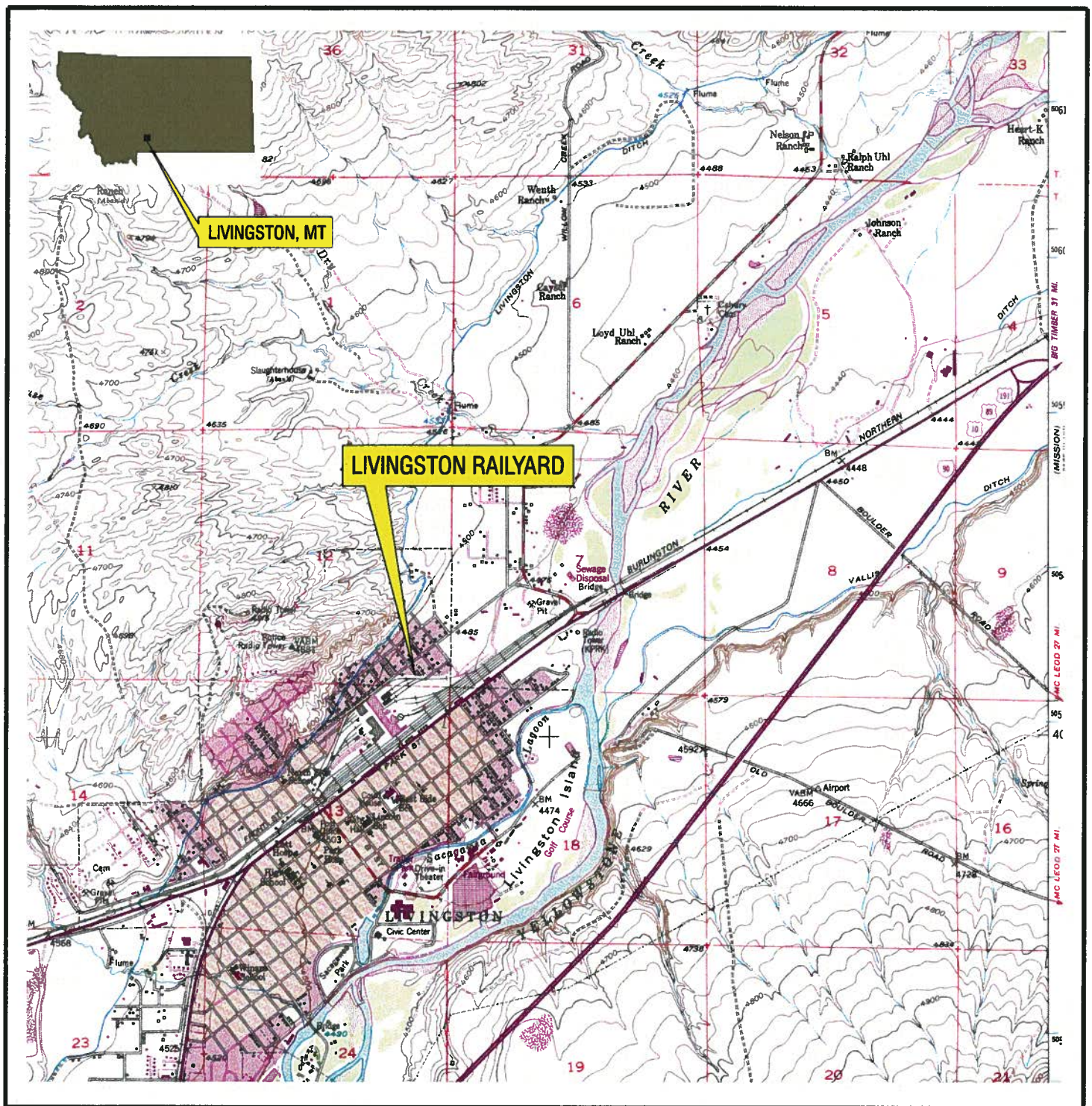
mg/kg – milligrams per kilogram

mg/L – milligrams per liter

µg/L – micrograms per liter

Figures





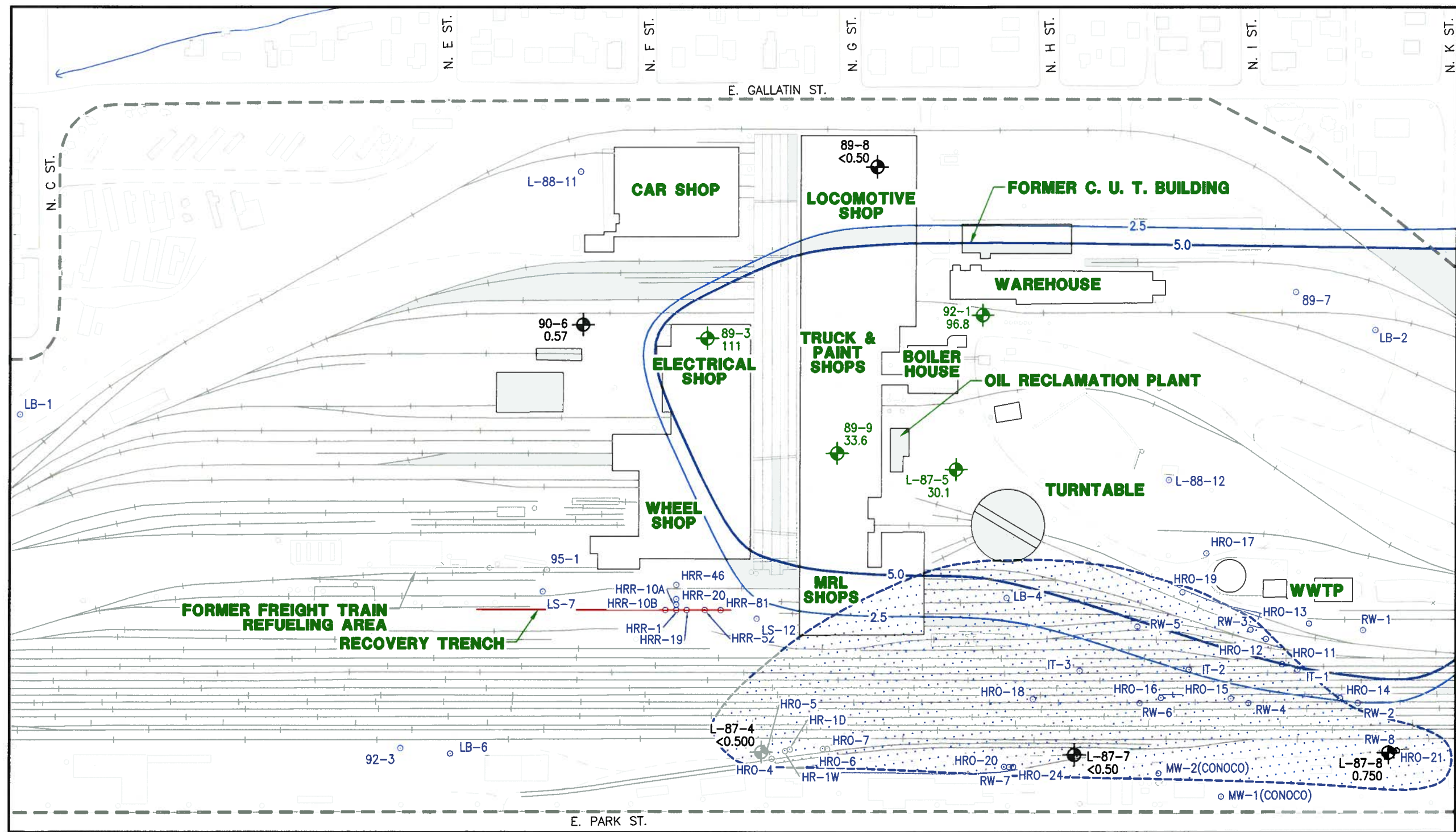
Kennedy/Jenks Consultants

BURLINGTON NORTHERN LIVINGSTON SHOP
COMPLEX – LIVINGSTON, MT

FACILITY LOCATION MAP

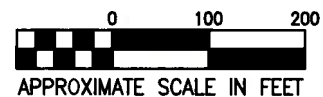
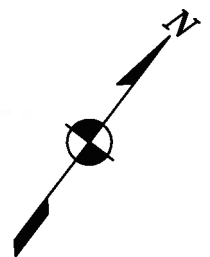
0896021.16/TASK F/PTWP/FIGURE 1r1
6/08 (REVISION No. 1) **FIGURE 1**

REFERENCE: USGS 7.5' TOPOGRAPHIC
QUADRANGLE LIVINGSTON, MONTANA 1951
PHOTO REVISED 1981



NOTES:

1) THE ISOCONCENTRATION CONTOURS SHOWN ON THIS DRAWING ARE INTENDED TO PROVIDE A GENERALIZED REPRESENTATION OF POTENTIAL SITE CONDITIONS AT ANY GIVEN TIME DURING THE PERIOD DURING WHICH DATA USED TO GENERATE THE MAP WERE ACQUIRED. CONTOURS DEPICTED WERE COMPUTER GENERATED USING ARC/INFO pc-TIN 3.40 BASED ON AVAILABLE DATA POINTS AND, THEREFORE, INCLUDE ANOMALIES THAT ARE NOT CONSISTENT WITH THE EXPECTED ACTUAL CHEMICAL CONCENTRATION DISTRIBUTION IN GROUNDWATER. THE ACTUAL DISTRIBUTION OF CHEMICAL CONCENTRATIONS IN GROUNDWATER CANNOT BE ACCURATELY DEPICTED USING TWO-DIMENSIONAL CONTOURING AND ESTIMATION METHODS SUCH AS THOSE USED TO PREPARE THIS DRAWING. THIS DRAWING IS INTENDED TO SERVE ONLY AS A GENERALIZED OR IDEALIZED REPRESENTATION OF SITE CONDITIONS TO ASSIST THE VIEWER IN VISUALIZING SITE CONDITIONS. THE CONTOURS DO NOT REPRESENT ANY PARTICULAR STATISTICAL CERTAINTY OF THE PRESENCE OR ABSENCE OF DETECTABLE CHEMICAL CONCENTRATIONS IN GROUNDWATER AT THE LOCATIONS SHOWN, NOR IS ANY WARRANTY OR GUARANTY, EXPRESSED OR IMPLIED, MADE BY KENNEDY/JENKS CONSULTANTS OR BNSF WITH RESPECT TO THE ACCURACY OF THIS DRAWING.



BASEMAP SOURCE:

HORIZONS, INC. RAPID, SD (1989)

LEGEND

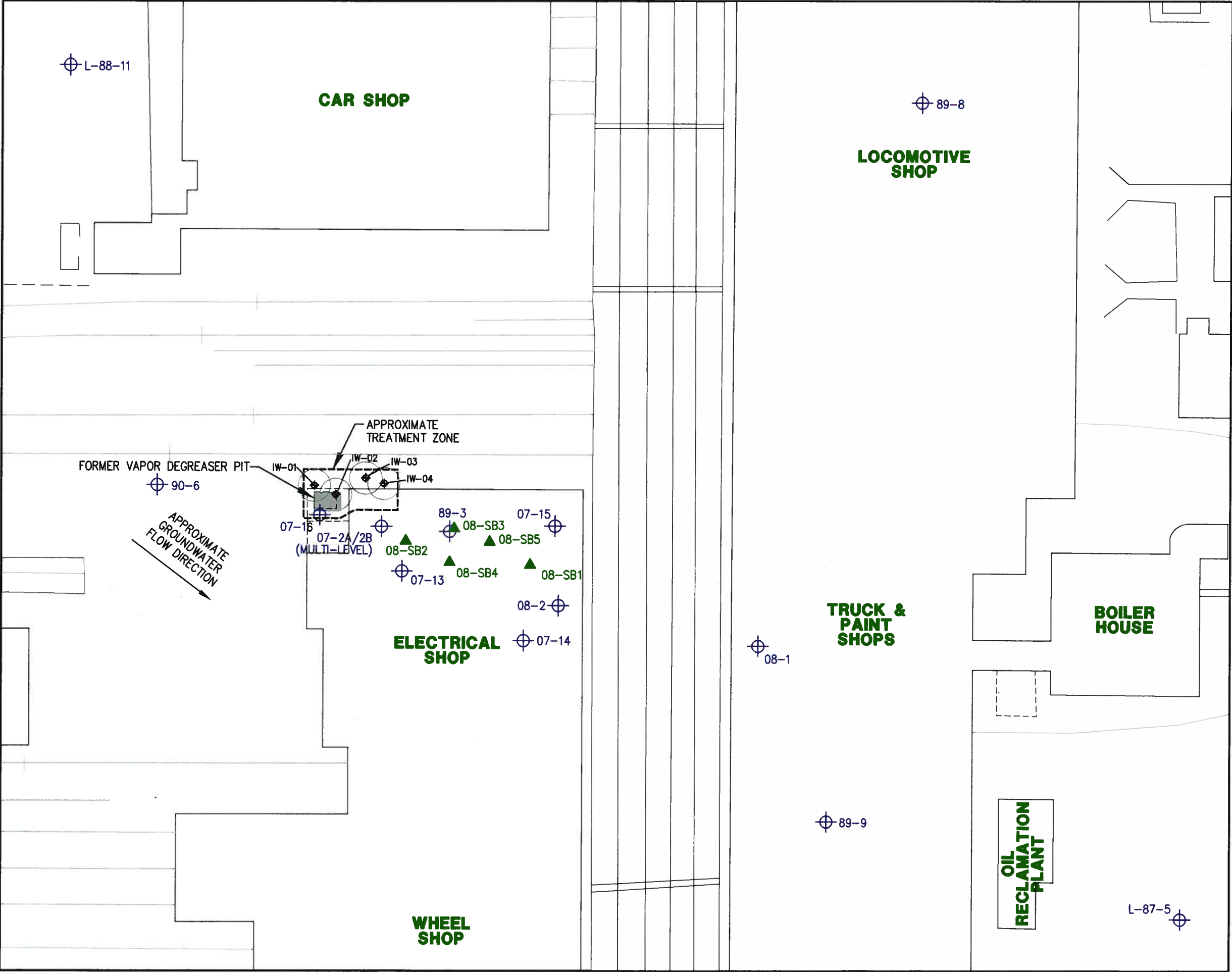
- L-88-10 24.1 MONITORING WELL AND PCE CONCENTRATION IN MICROGRAMS PER LITER ($\mu\text{g/L}$) – NOVEMBER 2004 GROUNDWATER SAMPLING EVENT
- L-87-7 <0.50 MONITORING WELL AND PCE CONCENTRATION ($\mu\text{g/L}$) NOT SAMPLED FOR PCE DURING NOVEMBER 2004 EVENT; THEREFORE, MOST RECENT DATA AVAILABLE USED
- LB-6 ○ INVESTIGATIVE WELL LOCATION
- "<" INDICATES NO PCE DETECTED

- LIVINGSTON RAILYARD BOUNDARY
- 2.5 ESTIMATED PCE ISOCONCENTRATION CONTOUR BASED ON NOVEMBER 2004 DATA ($\mu\text{g/L}$)
- 5.0 ESTIMATED ISOCONCENTRATION CONTOUR FOR PCE CLEANUP LEVEL PER THE RECORD OF DECISION BASED ON NOVEMBER 2004 DATA ($\mu\text{g/L}$)
- ESTIMATED EXTENT OF MEASURABLE APPARENT LNAPL THICKNESS

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BURLINGTON NORTHERN LIVINGSTON SHOP
COMPLEX – LIVINGSTON, MT

LIVINGSTON RAILYARD FEATURES



LEGEND

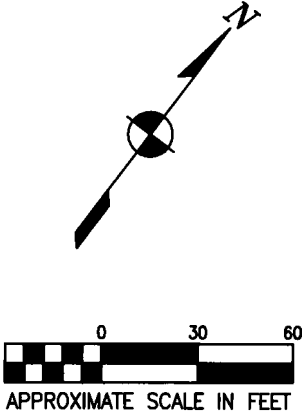
IW-01 PROPOSED PERMANGANATE INJECTION BORING

ESTIMATED RADIUS OF INFLUENCE = 10 FEET

89-3 EXISTING MONITORING WELL LOCATION

08-SB4 SOIL BORING LOCATION

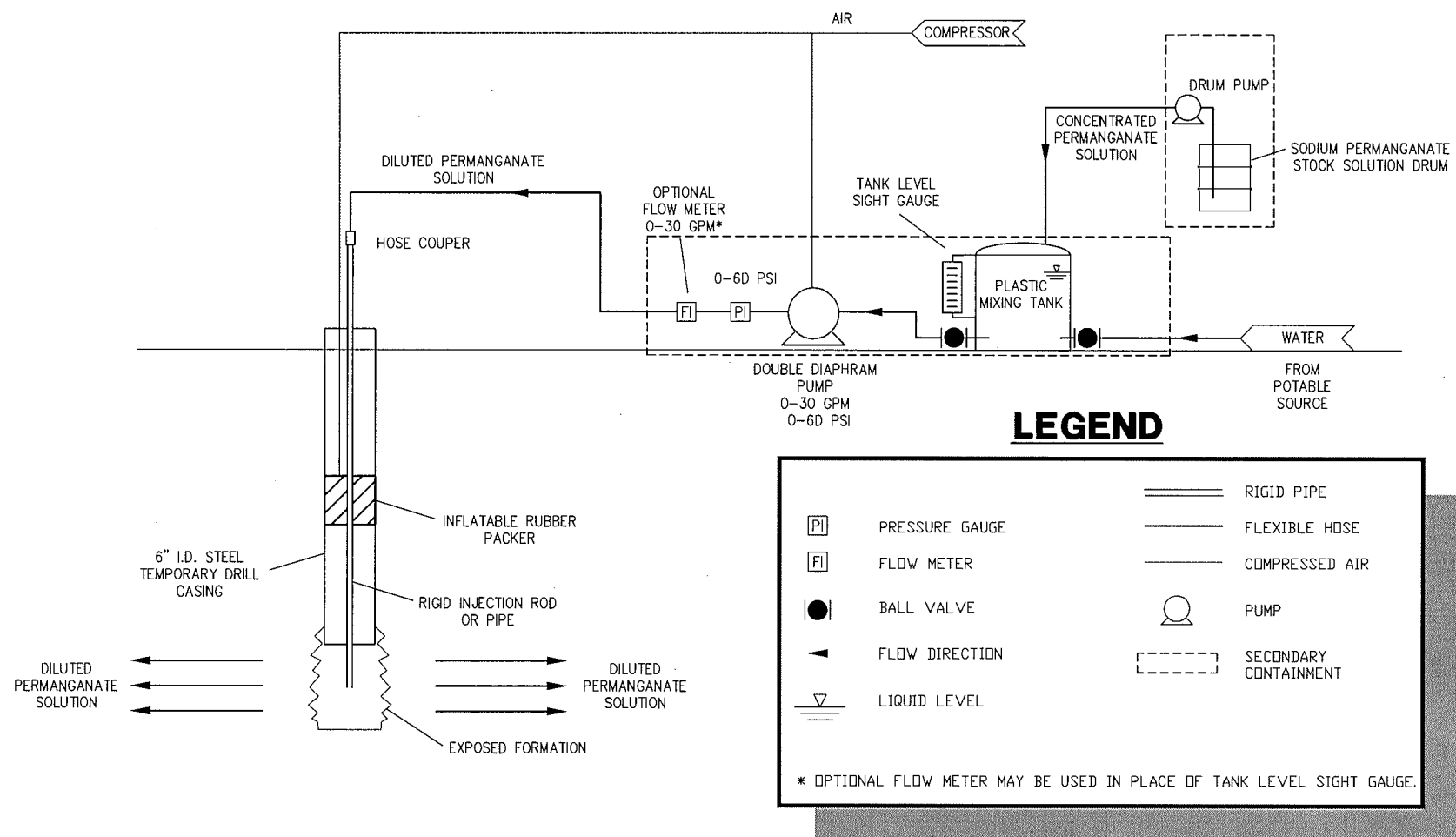
NOTE:
1) ALL LOCATIONS ARE APPROXIMATE



BASEMAP SOURCE:
HORIZONS, INC. RAPID, SD (1989)

Kennedy/Jenks Consultants
BURLINGTON NORTHERN LIVINGSTON SHOP
COMPLEX – LIVINGSTON, MT

**PROPOSED INJECTION AND
MONITORING WELL LOCATIONS**



Kennedy/Jenks Consultants

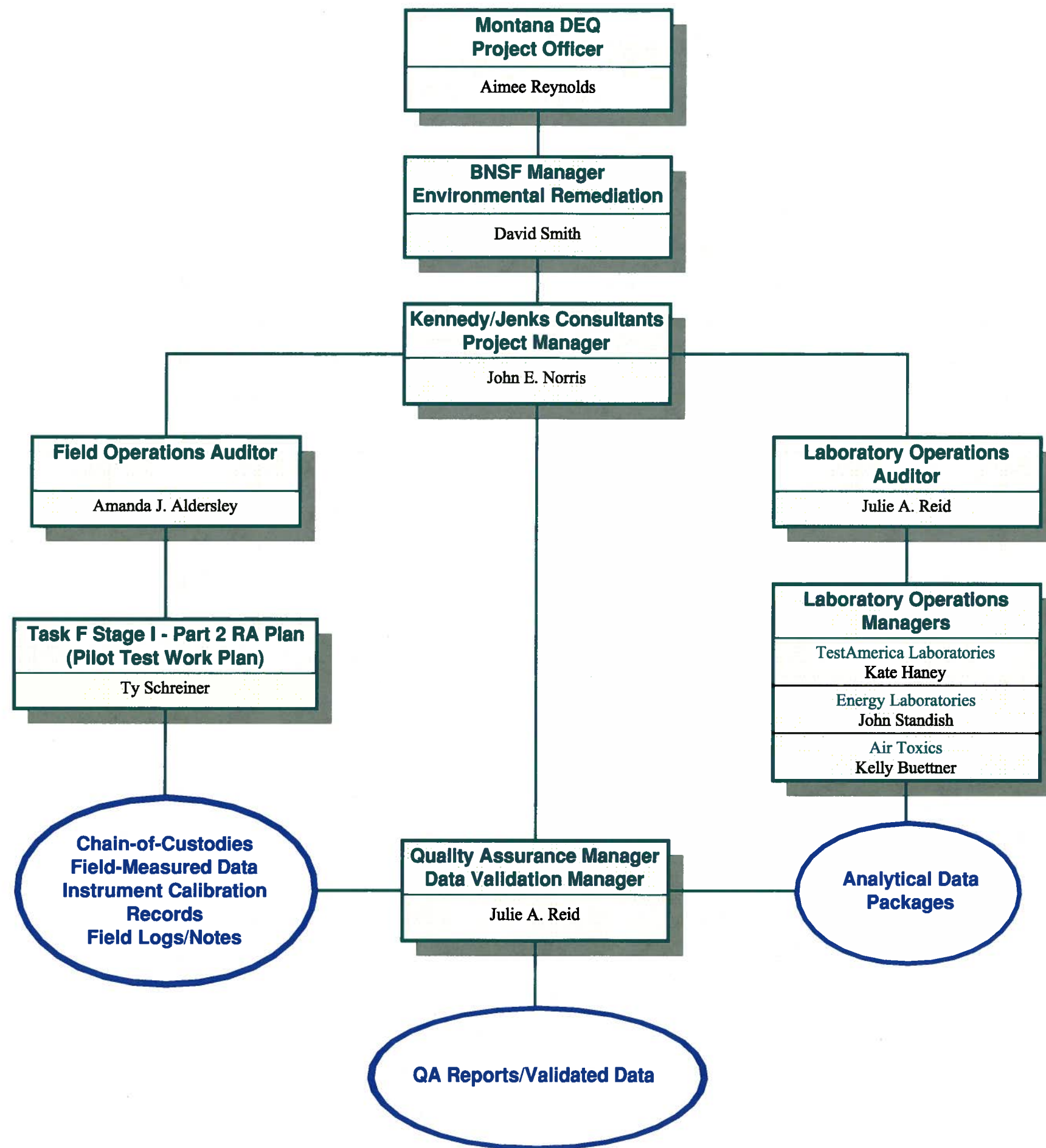
BURLINGTON NORTHERN LIVINGSTON SHOP
COMPLEX – LIVINGSTON, MT

NaMnO₄ INJECTION SYSTEM SCHEMATIC

0696021.16/TASK F/PT WP/FIGURE 4r1

6/08 (REVISION NO. 1)

FIGURE 4



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BURLINGTON NORTHERN LIVINGSTON SHOP
COMPLEX – LIVINGSTON, MT

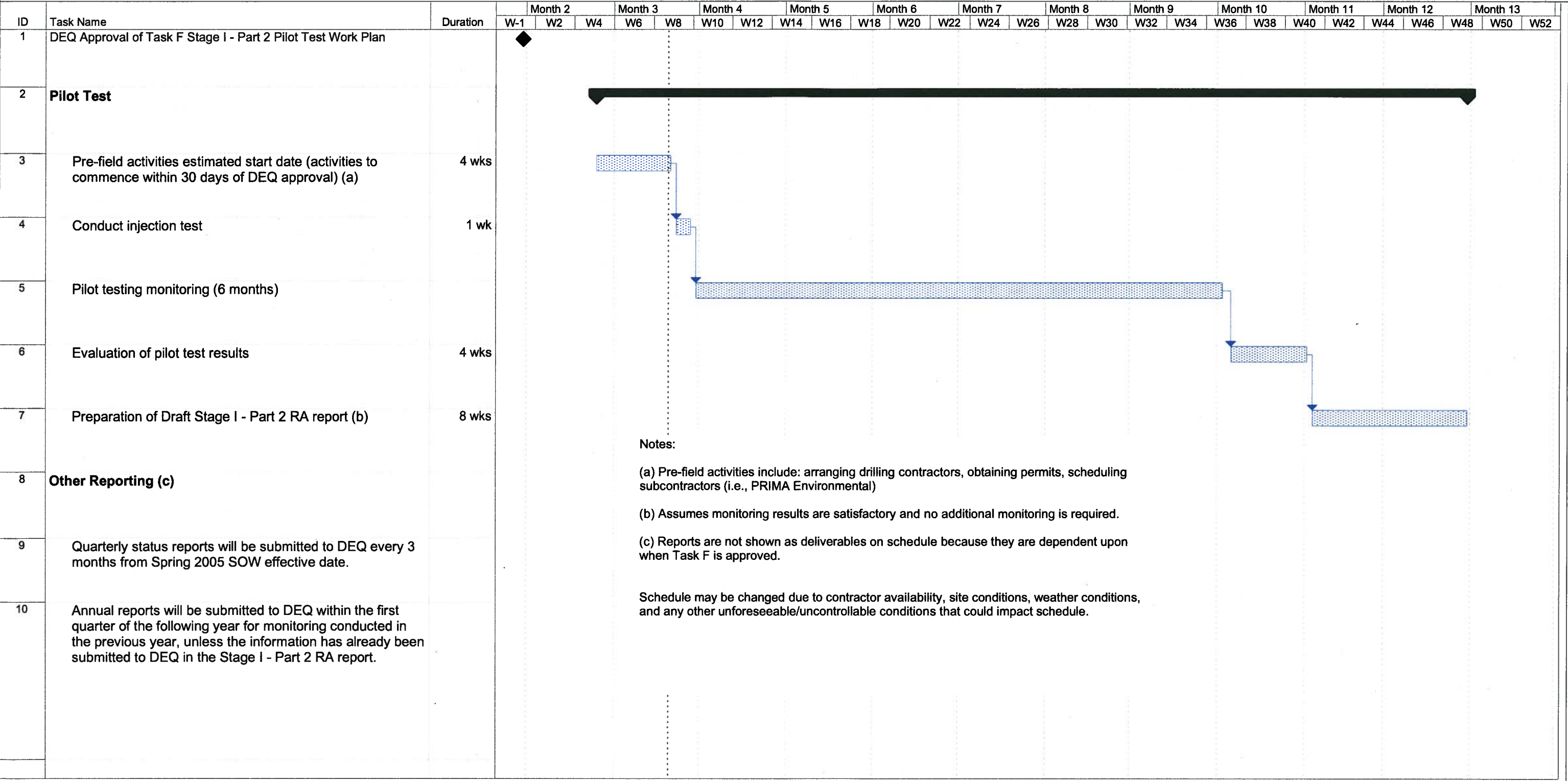
PROJECT ORGANIZATION CHART

0896021.16/TASK F/PT WP/FIGURE 5r1

6/08 (REVISION NO. 1) **FIGURE 5**

**Figure 6
Preliminary Schedule**

Task F (Stage I - Part 2) - Pilot Test



Task

Progress

Summary

External Tasks

Deadline

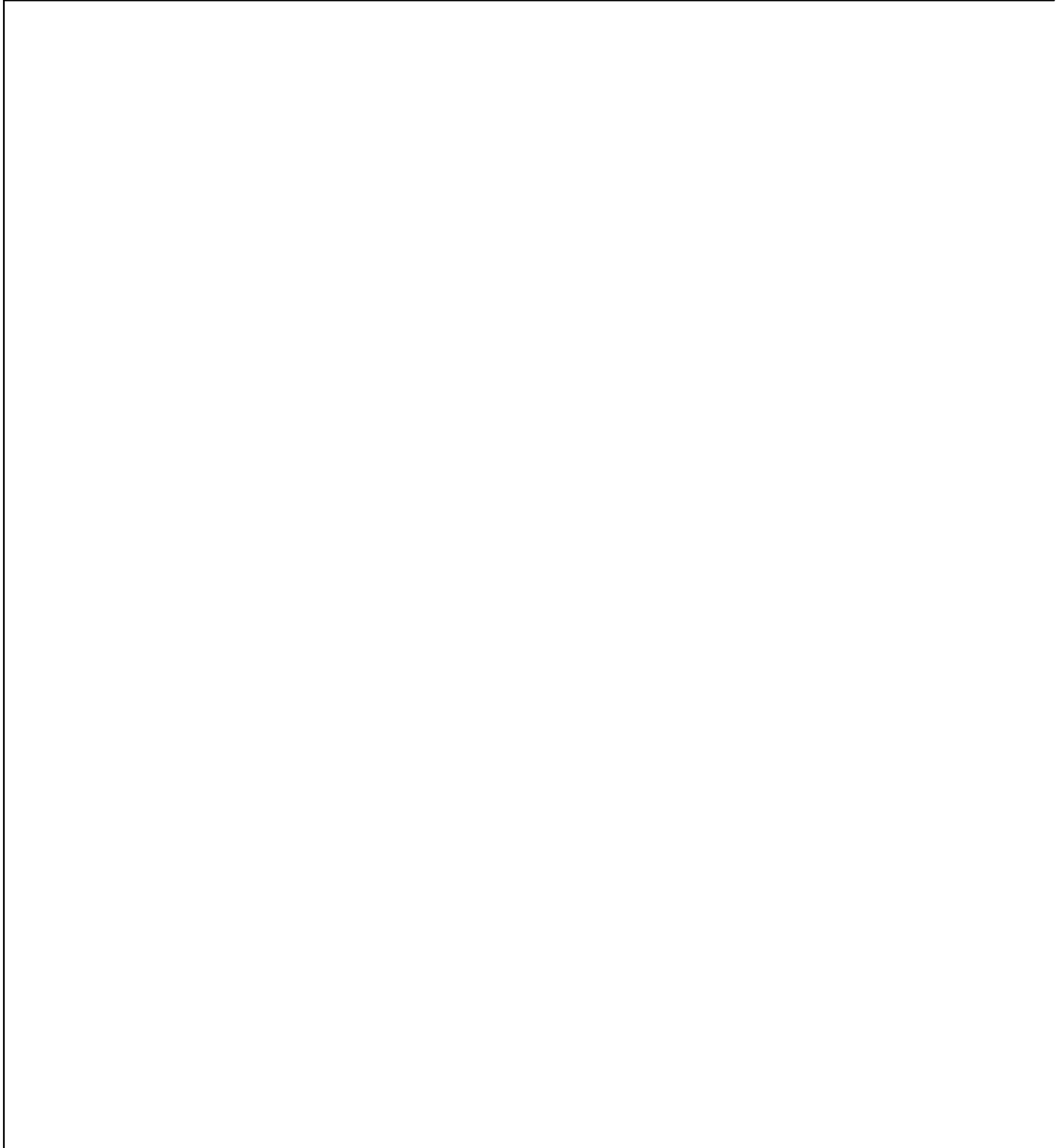
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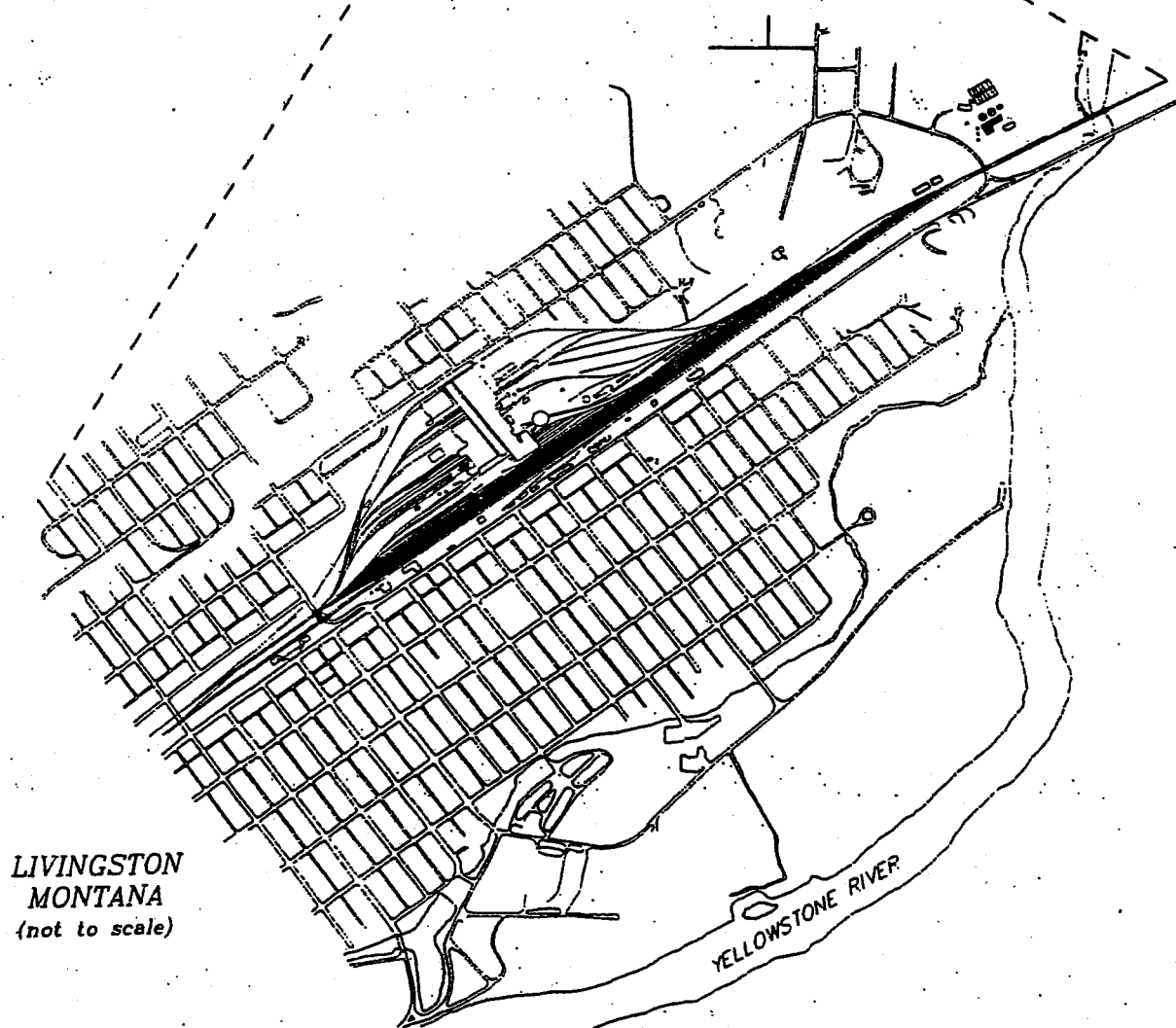
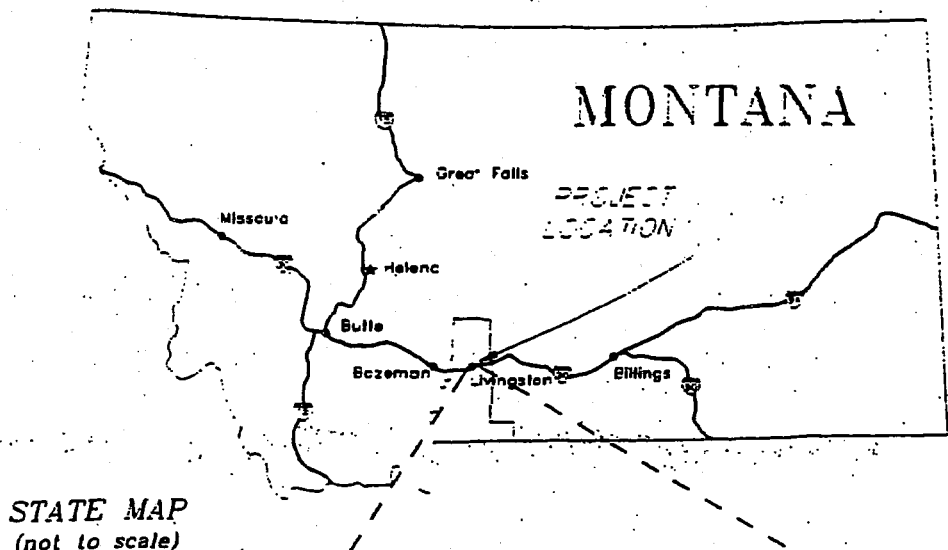
Milestone

Project Summary

External Milestone

ROD Figure





BURLINGTON NORTHERN SANTA FE RAILROAD COMPANY	FINAL PRIMARY HYDROCARBON FEASIBILITY STUDY REPORT LIVINGSTON RAIL YARD LIVINGSTON, MONTANA		LIVINGSTON RAILYARD SITE LOCATION MAP	
ENVIROCON, INC.	JOB # 140101.R02	12/30/97	FIGURE 1.	

Appendix A

Potentiometric Surface Contours June and November 2004



LEGEND

L-88-13
4467.64

MONITORING WELL LOCATION AND WATER LEVEL
ELEVATION (FEET ABOVE MSL)

(4470.11)

ELEVATION IN PARENTHESIS NOT USED IN INTERPOLATION

4482

APPROXIMATE POTENTIOMETRIC SURFACE ELEVATION
CONTOURS BASED ON MEASUREMENTS TAKEN
JUNE 2004.
INTERPOLATION BASED ON TRIANGULATED IRREGULAR
NETWORK USING pc-TIN 3.4D (FEET ABOVE MSL)

CONTOUR INTERVAL = 2 FEET

BASEMAP SOURCE:

HORIZONS, INC. RAPID, SD (1989)

0 400 800
APPROXIMATE SCALE IN FEET

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BURLINGTON NORTHERN LIVINGSTON SHOP
COMPLEX – LIVINGSTON, MT

**POTENTIOMETRIC SURFACE CONTOURS
JUNE 2004**


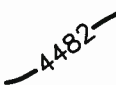
0896021.16/TASK F/PT WP/FIGURE A1r1

6/08 (REVISION NO. 1)

FIGURE A1




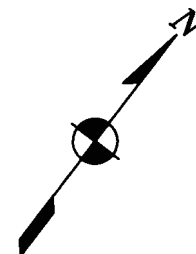
LEGEND

- L-88-13
4467.87  MONITORING WELL LOCATION AND WATER LEVEL
ELEVATION (FEET ABOVE MSL)
- (4460.11) ELEVATION IN PARENTHESIS NOT USED IN INTERPOLATION
-  4482 APPROXIMATE POTENTIOMETRIC SURFACE ELEVATION
CONTOURS BASED ON MEASUREMENTS TAKEN
NOVEMBER 2004.
INTERPOLATION BASED ON TRIANGULATED IRREGULAR
NETWORK USING pc-TIN 3.4D (FEET ABOVE MSL)

CONTOUR INTERVAL = 2 FEET

BASEMAP SOURCE:
HORIZONS, INC. RAPID, SD (1989)

0 400 800

APPROXIMATE SCALE IN FEET



Kennedy/Jenks Consultants

BURLINGTON NORTHERN LIVINGSTON SHOP
COMPLEX – LIVINGSTON, MT

**POTENTIOMETRIC SURFACE CONTOURS
NOVEMBER 2004**

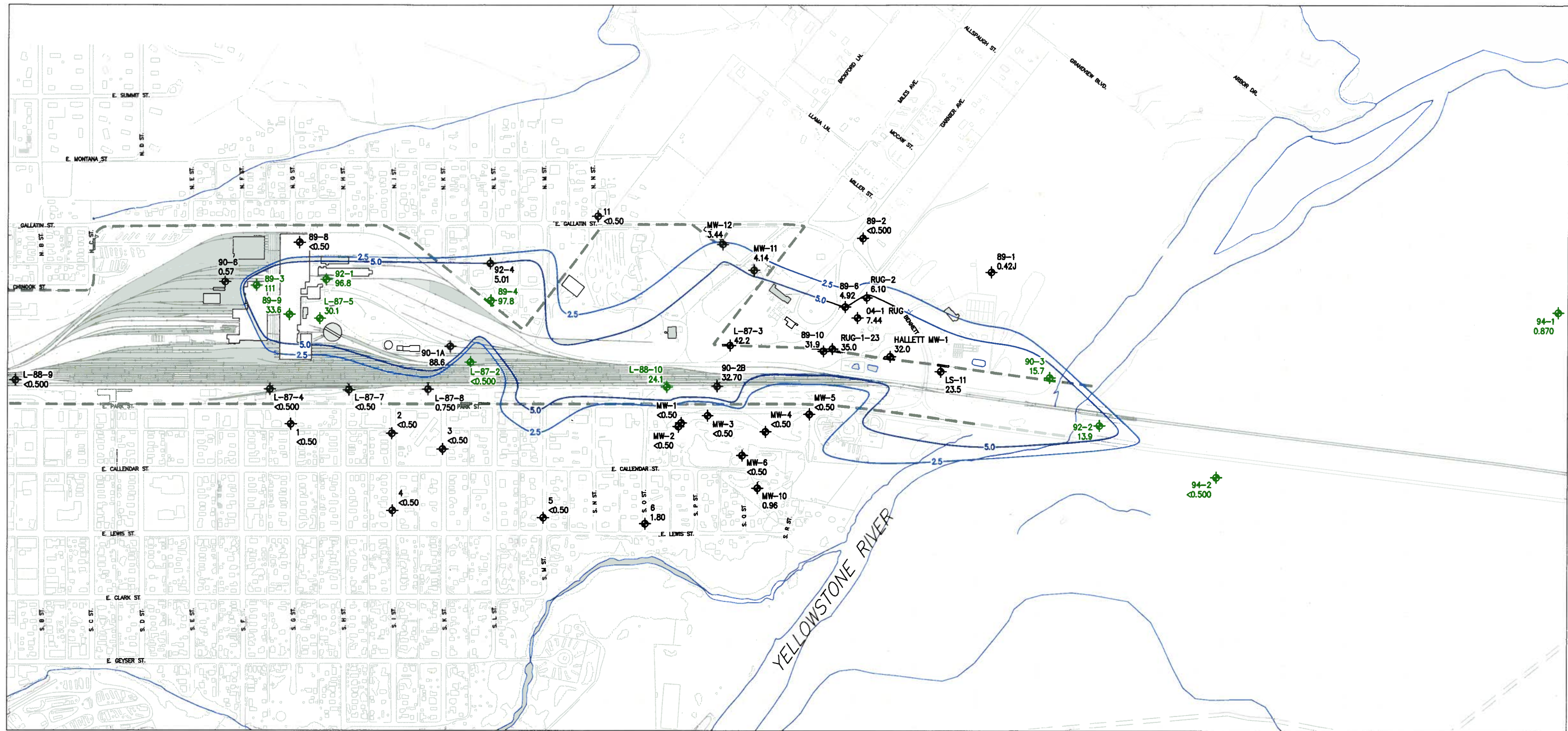
0896021.16/TASK F/PT WP/FIGURE A2r1

6/08 (REVISION NO. 1)

FIGURE A2

Appendix B

Isoconcentration Maps for PCE, TCE, and cis-1,2-DCE June and November 2004



LEGEND

- ◆ L-88-10 24.1 MONITORING WELL AND PCE CONCENTRATION IN MICROGRAMS PER LITER (µg/L) – NOVEMBER 2004
- ◆ L-87-7 <0.50 MONITORING WELL AND PCE CONCENTRATION (µg/L) NOT SAMPLED FOR PCE DURING NOVEMBER 2004 EVENT; THEREFORE, MOST RECENT DATA AVAILABLE USED
- "<" INDICATES NO PCE DETECTED
- LIVINGSTON RAILYARD BOUNDARY
- 2.5— ESTIMATED PCE ISOCONCENTRATION CONTOUR (µg/L)
- 5.0— ESTIMATED ISOCONCENTRATION CONTOUR FOR PCE CLEANUP LEVEL PER THE RECORD OF DECISION (µg/L)

NOTES:

1) THE ISOCONCENTRATION CONTOURS SHOWN ON THIS DRAWING ARE INTENDED TO PROVIDE A GENERALIZED REPRESENTATION OF POTENTIAL SITE CONDITIONS AT ANY GIVEN TIME DURING THE PERIOD DURING WHICH DATA USED TO GENERATE THE MAP WERE ACQUIRED. CONTOURS DEPICTED WERE COMPUTER GENERATED USING ARC/INFO pc-TIN 3.4D BASED ON AVAILABLE DATA POINTS AND, THEREFORE, INCLUDE ANOMALIES THAT ARE NOT CONSISTENT WITH THE EXPECTED ACTUAL CHEMICAL CONCENTRATION DISTRIBUTION IN GROUNDWATER. THE ACTUAL DISTRIBUTION OF CHEMICAL CONCENTRATIONS IN GROUNDWATER CANNOT BE ACCURATELY DEPICTED USING TWO-DIMENSIONAL CONTOURING AND ESTIMATION METHODS SUCH AS THOSE USED TO PREPARE THIS DRAWING. THIS DRAWING IS INTENDED TO SERVE ONLY AS A GENERALIZED OR IDEALIZED REPRESENTATION OF SITE CONDITIONS TO ASSIST THE VIEWER IN VISUALIZING SITE CONDITIONS. THE CONTOURS DO NOT REPRESENT ANY PARTICULAR STATISTICAL CERTAINTY OF THE PRESENCE OR ABSENCE OF DETECTABLE CHEMICAL CONCENTRATIONS IN GROUNDWATER AT THE LOCATIONS SHOWN, NOR IS ANY WARRANTY OR GUARANTY, EXPRESSED OR IMPLIED, MADE BY KENNEDY/JENKS CONSULTANTS OR BNSF WITH RESPECT TO THE ACCURACY OF THIS DRAWING.

BASEMAP SOURCE:
HORIZONS, INC. RAPID, SD (1989)

0 350 700
APPROXIMATE SCALE IN FEET

Kennedy/Jenks Consultants

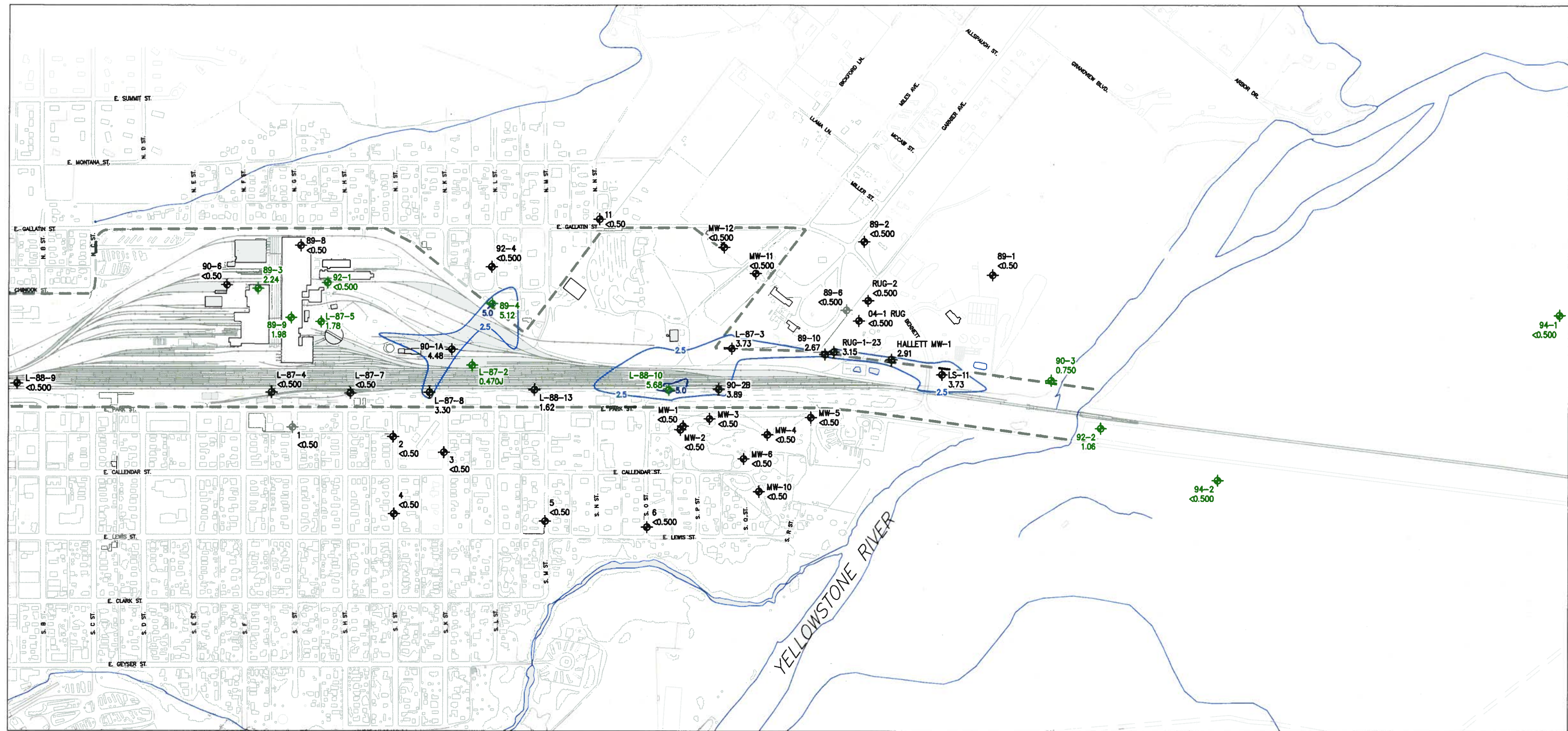
BURLINGTON NORTHERN LIVINGSTON SHOP
COMPLEX – LIVINGSTON, MT

**TETRACHLOROETHENE (PCE)
CONCENTRATIONS AND DISTRIBUTION
NOVEMBER 2004**

0896021.16/TASK F/PT WP/FIGURE B2r1

6/08 (REVISION NO. 1)

FIGURE B2



LEGEND

- 89-4 5.12 MONITORING WELL AND TCE CONCENTRATION IN MICROGRAMS PER LITER ($\mu\text{g/L}$) – NOVEMBER 2004
- 1 <0.50 MONITORING WELL AND TCE CONCENTRATION ($\mu\text{g/L}$) NOT SAMPLED FOR TCE DURING NOVEMBER 2004 EVENT; THEREFORE, MOST RECENT DATA AVAILABLE USED
- "<" INDICATES NO TCE DETECTED
- LIVINGSTON RAILYARD BOUNDARY
- 2.5 ESTIMATED TCE ISOCONCENTRATION CONTOUR ($\mu\text{g/L}$)
- 5.0 ESTIMATED ISOCONCENTRATION CONTOUR FOR TCE CLEANUP LEVEL PER THE RECORD OF DECISION ($\mu\text{g/L}$)

NOTES:

1) THE ISOCONCENTRATION CONTOURS SHOWN ON THIS DRAWING ARE INTENDED TO PROVIDE A GENERALIZED REPRESENTATION OF POTENTIAL SITE CONDITIONS AT ANY GIVEN TIME DURING THE PERIOD DURING WHICH DATA USED TO GENERATE THE MAP WERE ACQUIRED. CONTOURS DEPICTED WERE COMPUTER GENERATED USING ARC/INFO pc-TIN 3.40 BASED ON AVAILABLE DATA POINTS AND, THEREFORE, INCLUDE ANOMALIES THAT ARE NOT CONSISTENT WITH THE EXPECTED ACTUAL CHEMICAL CONCENTRATION DISTRIBUTION IN GROUNDWATER. THE ACTUAL DISTRIBUTION OF CHEMICAL CONCENTRATIONS IN GROUNDWATER CANNOT BE ACCURATELY DEPICTED USING TWO-DIMENSIONAL CONTOURING AND ESTIMATION METHODS SUCH AS THOSE USED TO PREPARE THIS DRAWING. THIS DRAWING IS INTENDED TO SERVE ONLY AS A GENERALIZED OR IDEALIZED REPRESENTATION OF SITE CONDITIONS TO ASSIST THE VIEWER IN VISUALIZING SITE CONDITIONS. THE CONTOURS DO NOT REPRESENT ANY PARTICULAR STATISTICAL CERTAINTY OF THE PRESENCE OR ABSENCE OF DETECTABLE CHEMICAL CONCENTRATIONS IN GROUNDWATER AT THE LOCATIONS SHOWN, NOR IS ANY WARRANTY OR GUARANTY, EXPRESSED OR IMPLIED, MADE BY KENNEDY/JENKS CONSULTANTS OR BNSF WITH RESPECT TO THE ACCURACY OF THIS DRAWING.

BASEMAP SOURCE:
HORIZONS, INC. RAPID, SD (1989)

0 350 700
APPROXIMATE SCALE IN FEET

Kennedy/Jenks Consultants

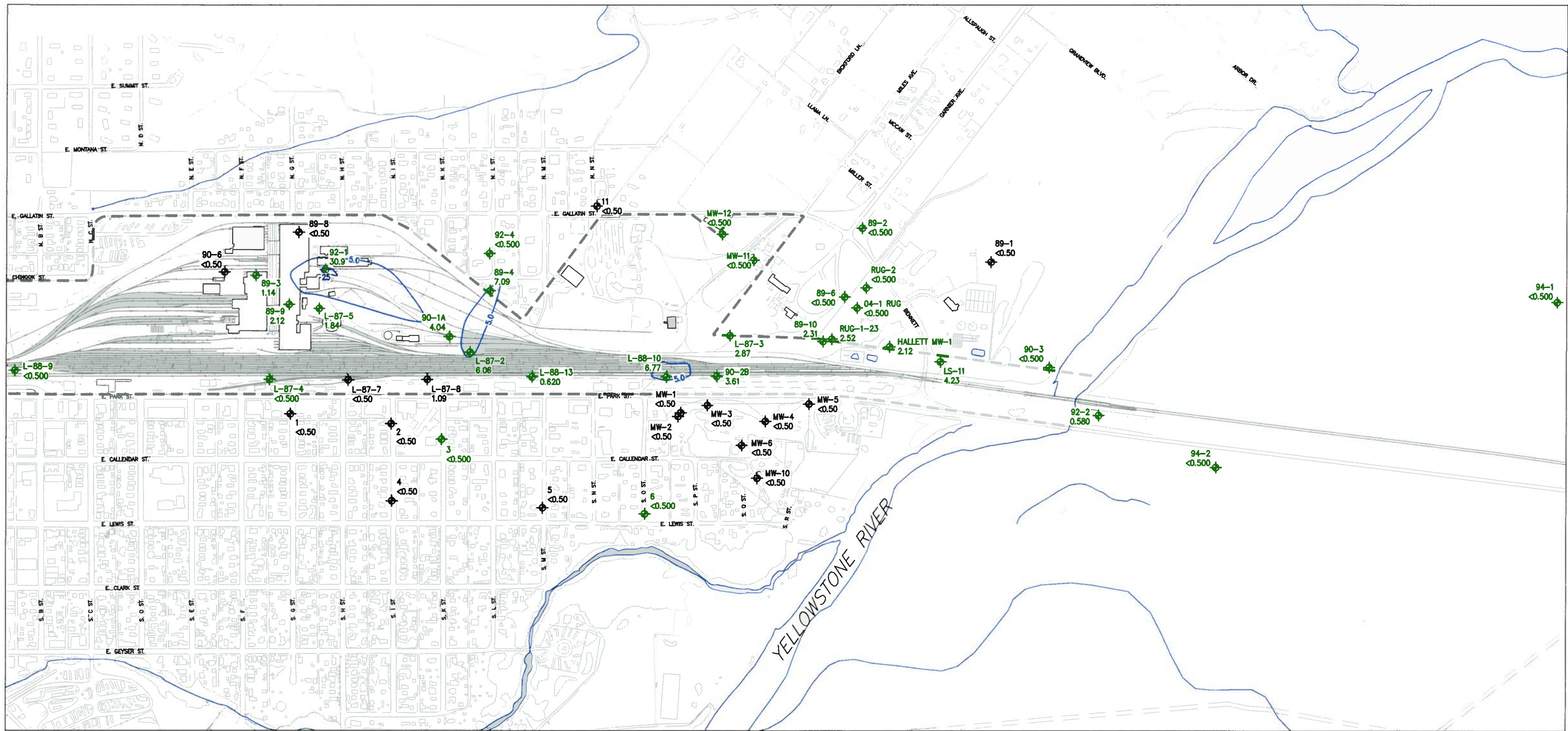
BURLINGTON NORTHERN LIVINGSTON SHOP
COMPLEX – LIVINGSTON, MT

**TRICHLOROETHENE (TCE)
CONCENTRATIONS AND DISTRIBUTION
NOVEMBER 2004**

0896021.16/TASK F/PT WP/FIGURE B4r1

6/08 (REVISION NO. 1)

FIGURE B4



LEGEND

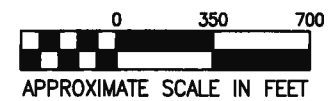
- 89-4 7.04 MONITORING WELL AND cis-1,2-DCE CONCENTRATION IN MICROGRAMS PER LITER (µg/L) – JUNE 2004
- 1 <0.50 MONITORING WELL AND cis-1,2-DCE CONCENTRATION (µg/L) NOT SAMPLED FOR cis-1,2-DCE DURING JUNE 2004 EVENT; THEREFORE, MOST RECENT DATA AVAILABLE USED
- "<" INDICATES NO cis-1,2-DCE DETECTED
- LIVINGSTON RAILYARD BOUNDARY
- 5.0 ESTIMATED cis-1,2-DCE ISOCONCENTRATION CONTOUR (µg/L)
- 25 ESTIMATED ISOCONCENTRATION CONTOUR FOR cis-1,2-DCE (µg/L)

NOTES:

1) THE ISOCONCENTRATION CONTOURS SHOWN ON THIS DRAWING ARE INTENDED TO PROVIDE A GENERALIZED REPRESENTATION OF POTENTIAL SITE CONDITIONS AT ANY GIVEN TIME DURING THE PERIOD DURING WHICH DATA USED TO GENERATE THE MAP WERE ACQUIRED. CONTOURS DEPICTED WERE COMPUTER GENERATED USING ARC/INFO pc-TIN 3.40 BASED ON AVAILABLE DATA POINTS AND, THEREFORE, INCLUDE ANOMALIES THAT ARE NOT CONSISTENT WITH THE EXPECTED ACTUAL CHEMICAL CONCENTRATION DISTRIBUTION IN GROUNDWATER. THE ACTUAL DISTRIBUTION OF CHEMICAL CONCENTRATIONS IN GROUNDWATER CANNOT BE ACCURATELY DEPICTED USING TWO-DIMENSIONAL CONTOURING AND ESTIMATION METHODS SUCH AS THOSE USED TO PREPARE THIS DRAWING. THIS DRAWING IS INTENDED TO SERVE ONLY AS A GENERALIZED OR IDEALIZED REPRESENTATION OF SITE CONDITIONS TO ASSIST THE VIEWER IN VISUALIZING SITE CONDITIONS. THE CONTOURS DO NOT REPRESENT ANY PARTICULAR STATISTICAL CERTAINTY OF THE PRESENCE OR ABSENCE OF DETECTABLE CHEMICAL CONCENTRATIONS IN GROUNDWATER AT THE LOCATIONS SHOWN, NOR IS ANY WARRANTY OR GUARANTY, EXPRESSED OR IMPLIED, MADE BY KENNEDY/JENKS CONSULTANTS OR BNSF WITH RESPECT TO THE ACCURACY OF THIS DRAWING.

BASEMAP SOURCE:

HORIZONS, INC. RAPID, SD (1989)



Kennedy/Jenks Consultants

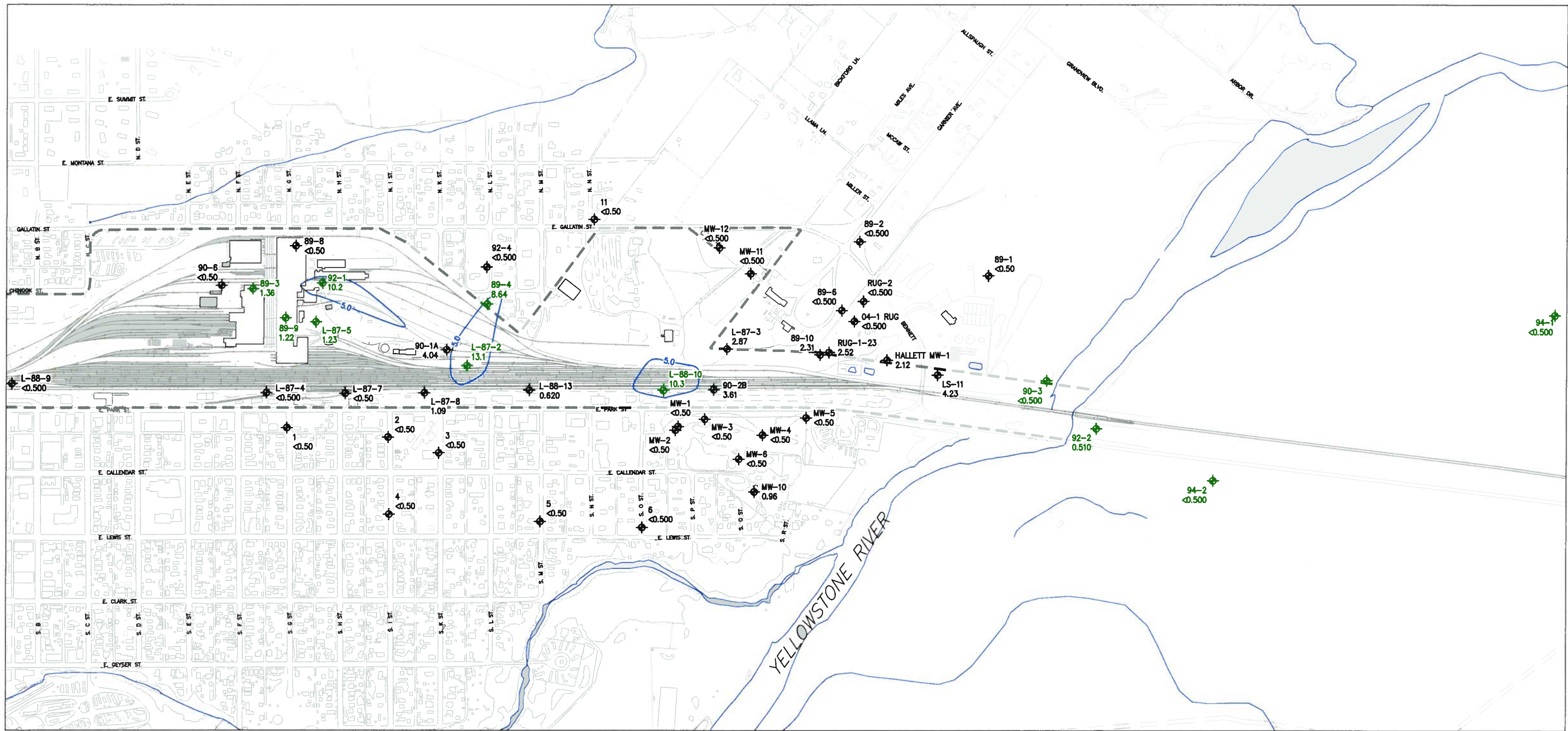
BURLINGTON NORTHERN LIVINGSTON SHOP COMPLEX – LIVINGSTON, MT

**cis-1,2-DICHLOROETHENE (cis-1,2-DCE)
CONCENTRATIONS AND DISTRIBUTION
JUNE 2004**

0896021.16/TASK F/PT WP/FIGURE B5r1

6/08 (Revision No. 1)

FIGURE B5



LEGEND

- 89-4 8.64 MONITORING WELL AND cis-1,2-DCE CONCENTRATION IN MICROGRAMS PER LITER (µg/L) – NOVEMBER 2004
- 1 MONITORING WELL AND cis-1,2-DCE CONCENTRATION (µg/L) NOT SAMPLED FOR cis-1,2-DCE DURING NOVEMBER 2004 EVENT; THEREFORE, MOST RECENT DATA AVAILABLE USED
- "<" INDICATES NO cis-1,2-DCE DETECTED
- LIVINGSTON RAILYARD BOUNDARY
- 5.0 ESTIMATED cis-1,2-DCE ISOCONCENTRATION CONTOUR (µg/L)

NOTES:

1) THE ISOCONCENTRATION CONTOURS SHOWN ON THIS DRAWING ARE INTENDED TO PROVIDE A GENERALIZED REPRESENTATION OF POTENTIAL SITE CONDITIONS AT ANY GIVEN TIME DURING THE PERIOD DURING WHICH DATA USED TO GENERATE THE MAP WERE ACQUIRED. CONTOURS DEPICTED WERE COMPUTER GENERATED USING ARC/INFO pc-TIN 3.40 BASED ON AVAILABLE DATA POINTS AND, THEREFORE, INCLUDE ANOMALIES THAT ARE NOT CONSISTENT WITH THE EXPECTED ACTUAL CHEMICAL CONCENTRATION DISTRIBUTION IN GROUNDWATER. THE ACTUAL DISTRIBUTION OF CHEMICAL CONCENTRATIONS IN GROUNDWATER CANNOT BE ACCURATELY DEPICTED USING TWO-DIMENSIONAL CONTOURING AND ESTIMATION METHODS SUCH AS THOSE USED TO PREPARE THIS DRAWING. THIS DRAWING IS INTENDED TO SERVE ONLY AS A GENERALIZED OR IDEALIZED REPRESENTATION OF SITE CONDITIONS TO ASSIST THE VIEWER IN VISUALIZING SITE CONDITIONS. THE CONTOURS DO NOT REPRESENT ANY PARTICULAR STATISTICAL CERTAINTY OF THE PRESENCE OR ABSENCE OF DETECTABLE CHEMICAL CONCENTRATIONS IN GROUNDWATER AT THE LOCATIONS SHOWN, NOR IS ANY WARRANTY OR GUARANTY, EXPRESSED OR IMPLIED, MADE BY KENNEDY/JENKS CONSULTANTS OR BNSF WITH RESPECT TO THE ACCURACY OF THIS DRAWING.

BASEMAP SOURCE:
HORIZONS, INC. RAPID, SD (1989)

0 350 700
APPROXIMATE SCALE IN FEET

Kennedy/Jenks Consultants

BURLINGTON NORTHERN LIVINGSTON SHOP
COMPLEX – LIVINGSTON, MT

**cis-1,2-DICHLOROETHENE (cis-1,2-DCE)
CONCENTRATIONS AND DISTRIBUTION
NOVEMBER 2004**

0896021.16/TASK F/PT WP/FIGURE B6r1

6/08 (Revision No. 1) **FIGURE B6**

Appendix C

Bench-Scale Test Standard Operating Procedures (SOPs) and Prima Environmental Introductory Information

Standard Operating Procedures Attenuation of Hexavalent Chromium

Revised
February 17, 2005

Strong oxidants such as potassium permanganate, ozone, and Fenton's reagent (ferrous iron and hydrogen peroxide) can oxidize soil chromium to water soluble hexavalent chromium, Cr(VI). The ability of this Cr(VI) to naturally attenuate is site-specific.

This Standard Operating Procedure describes the procedures used to evaluate the ability of Cr(VI) to naturally attenuate after exposure to an oxidant. Tests will assess whether Cr(VI) can naturally attenuate in the treatment zone and downgradient of the treatment zone. Tests to evaluate both scenarios are proposed because oxidants are typically non-selective, which might make soil within the treatment zone less able to attenuate Cr(VI) than soil immediately downgradient of the treatment zone.

Notes

- **Within the Treatment Zone vs. Downgradient of the Treatment Zone.** Tests using treated soil simulate conditions within the treatment zone, while tests using untreated soil simulate conditions downgradient of the treatment zone.
- **Measurement of Cr(VI).** Cr(VI) will be analyzed colorimetrically by PRIMA Environmental using a Hach DR 2100 Spectrophotometer and appropriate Hach test reagents unless otherwise specified in the project Scope of Work (SOW). Total chromium will NOT be measured.

Materials

- **1000 mg/L Cr(VI) standard in deionized water.** Obtain from VWR or other chemical supplier.
- **18.0 N H₃PO₄ solution.** Obtained from VWR or other chemical supplier.
- **10 mM phosphoric acid (H₃PO₄).** Place 0.83 mL of 18.0 N H₃PO₄ solution in a 500 mL volumetric flask. Dilute to the mark with deionized water.
- **5 mg/L Cr(VI) Solution (for Available Reducing Capacity Tests).** Place 0.5 mL of 1000 mg/L Cr(VI) standard in a 100 mL volumetric flask. Fill to the mark with 10 mM H₃PO₄.
- **10 mg/L Cr(VI) Solution (for Available Reducing Capacity Tests).** Place 1.0 mL of 1000 mg/L Cr(VI) standard (in a 100 mL volumetric flask. Fill to the mark with 10 mM H₃PO₄.
- **20 mg/L Cr(VI) Solution (for Available Reducing Capacity Tests).** Place 2.0 mL of 1000 mg/L Cr(VI) standard in a 100 mL volumetric flask. Fill to the mark with 10 mM H₃PO₄.

Procedures

Available Cr(VI) Reducing Capacity of Soil

The available reducing capacity of treated and untreated soil will be measured using the method developed by Bartlett (Bartlett, R.J. 1991. "Chromium Cycling in Soils and Water: Links, Gaps and Methods," *Environmental Health Perspectives*, **92**, 17-24.).

1. Prepare two series of centrifuge tubes by filling three (3) tubes with 5 g of untreated soil and three (3) tubes with 5 g of treated soil.
2. Add 25 mL of 5 mg/L Cr(VI) solution to the first tube from each series.
3. Add 25 mL of 10 mg/L Cr(VI) solution to the second tube from each series.
4. Add 25 mL of 20 mg/L Cr(VI) solution to the third tube from each series.
5. Prepare three controls by adding 25 mL of each Cr(VI) solution to an empty centrifuge tube.
6. Cap the tubes and place on a shaker table.
7. After 18 hours, centrifuge the tubes.
8. Filter the aqueous phase through a 0.45 mm filter.
9. Analyze for Cr(VI) colorimetrically as noted above.

Long-term Fate of Cr(VI)

1. If necessary, repeat the test that generated the Cr(VI) using the procedures in the project SOW.
2. Separate the treated soil and treated groundwater by an appropriate method (usually centrifugation).
3. *Within the treatment zone.* Prepare 4 replicates containing treated soil and treated groundwater. The containers should be plastic screw-cap bottles. The amounts of soil and water depend upon the amount of material available, but should be such that the soil to liquid ratio is 1:1 (w/v).
4. *Downgradient of the treatment zone.* Prepare 4 replicates containing untreated soil and treated groundwater. The containers should be plastic screw-cap bottles. The amounts of soil and water depend upon the amount of material available, but should be such that the soil to liquid ratio is 1:1 (w/v).
5. Cap all bottles and place them on a shaker table.
6. Periodically, destructively sample one bottle and analyze the aqueous phase for Cr(VI). The sampling frequency is project-specific and may differ for treatment zone and downgradient replicates. Consult the SOW or project manager for sampling times.

Standard Operating Procedures PERMANGANATE TREATABILITY TESTING

Revised
February 17, 2005

Permanganate is an oxidant commonly used for *in situ* chemical oxidation (ISCO) of the chlorinated ethenes (PCE, TCE, DCE and Vinyl chloride). Other chlorinated compounds may also be susceptible to treatment by permanganate and may be evaluated during treatability testing.

Treatability testing typically consists of the following tasks:

- Soil and Groundwater preparation and characterization
- Measurement of soil oxidant demand (SOD)
- Evaluation of contaminant removal
- Assessment of the effect of permanganate on non-target compounds (secondary water quality parameters), especially the formation of hexavalent chromium. Cr(VI).
- Assessment of the potential for attenuation of Cr(VI)

A specific project may require all or some of these tasks, which are given in the project-specific Scope of Work (SOW).

Terminology

- “SOP” refers to “Standard Operating Procedures”
- “SOW” refers to a project-specific Scope of Work.
- “Permanganate” refers to potassium permanganate in all SOPs related to permanganate.
- “KMnO₄” refers to potassium permanganate.

Potassium Permanganate (KMnO₄) versus Sodium Permanganate (NaMnO₄).

All tests will be conducted using KMnO₄ unless otherwise specified in the project SOW.

Soil and Groundwater Preparation and Characterization

1. Prepare soil and groundwater according to the SOP “Soil and Groundwater Preparation” unless otherwise noted in the project SOW.
2. Characterize (analyze) prepared soil and groundwater per the project SOW. Use sampling procedures described in the SOP “Sample Collection”.

Soil Oxidant Demand

1. Measure SOD according to the SOP “Potassium Permanganate Soil Oxidant Demand”

Contaminant Removal and Effect on Secondary Water Quality

Batch tests will be conducted to determine whether KMnO_4 can destroy contaminants and to assess the effect on secondary water quality parameters. General procedures are described below. Refer to the project SOW and project manager for project specific details—such as reactor size, KMnO_4 concentration, and secondary water quality parameters of concern—and for project-specific modifications.

1. Prepare two series of reactors by combining soil and groundwater in glass media bottles with a screw-cap lid. The amounts should be such that the ratio of soil to total added aqueous phase is 1:5 (w/v).
2. To one series of reactors, add concentrated KMnO_4 solution to obtain the desired KMnO_4 loading. These are the “Test” reactors. To the other series, add an equal volume of deionized (DI) water. These are the “Controls”. The total volume of liquid (KMnO_4 solution or DI water plus groundwater) should be such that the soil to liquid ratio is 1:5 (w/v) and the headspace in the reactor is < 10 mL (in order to minimize potential losses due to volatilization).
3. To the remaining series of reactors, add the same volume of deionized water. This series will serve as the controls.
4. Cap the reactors and mix well.
5. Store upside down in the dark at room temperature (between 20-25°C).
6. Shake twice per day.
7. Periodically, destructively sample one reactor from each series and analyze for contaminants of concern and secondary water quality parameters as required by the project SOW. **ALWAYS collect VOC samples first** to minimize losses due to volatilization. Samples for other analytes may be collected in any order. Procedures for collecting samples for commonly analyzed constituents are given below. See project manager for procedures for other analytes.

Sample for VOCs, pH, and ORP as follows:

- a. Let soil settle.
- b. Decant a portion of the aqueous phase into HCl-preserved VOA vials for analysis of VOCs. If KMnO_4 is present in sample, quench the reaction by adding 300-400 mg of manganese sulfate (MnSO_4). Refrigerate until submitted to analytical laboratory.
- c. Decant a portion of the aqueous phase into a plastic bottle. Measure pH and ORP as soon as possible—24 hours maximum.

Sample for residual KMnO_4 as follows:

- d. Remove an aliquot (~10 mL) of the aqueous phase from glass reaction bottle.
- e. Filter through 0.45 μm syringe filter.
- f. Analyze for KMnO_4 per the SOP "Analysis of Potassium Permanganate".

Sample for Cr(VI) as follows:

- g. Centrifuge a portion of the remaining soil and water
- h. Filter at least 50 mL of the aqueous phase through a 0.45 μm filter.
- i. Analyze for Cr(VI) via the Hach test method and/or submit for analysis of Cr(VI) via EPA method 7199.

Notes on Cr(VI) analysis

- j. Hold time for Cr(VI) is 24 hours.
- k. **ALWAYS** analyze for Total Chromium if analyzing for Cr(VI) .
- l. Cr(VI) can not be measured if KMnO_4 is present because KMnO_4 interferes with the analysis

Sample for metals as follows:

- m. Centrifuge remaining soil and water
- n. Filter at least 100 mL through a 0.45 μm filter.
- o. Put filtered sample into an HNO_3 -preserved plastic bottle. Refrigerate until submitted to an analytical laboratory.

Sample for other parameters as follows:

- p. If time permits or if necessary for accurate measurement of analyte, filter remaining aqueous phase through a 0.45 μm filter.
- q. Distribute to sample containers appropriate for desired analysis. Refrigerate until submitted to an analytical laboratory.

Attenuation of Cr(VI)

See SOP "Attenuation of Hexavalent Chromium"

Standard Operating Procedures Sample Collection and Submittal to Outside Laboratories

Revised
February 15, 2005

This Standard Operating Procedure describes the procedures used to collect and submit soil and groundwater samples to an analytical laboratory.

Sample Collection and Preservation. Soil and groundwater samples to be analyzed by an outside laboratory will be collected using container type and preservative appropriate for the specific analysis. All sample containers will be new and pre-cleaned. The volume of sample, sample container type, and preservative will be determined by the analytical laboratory. If less sample is available, PRIMA will contact the analytical laboratory to determine whether the analysis can be run.

See specific treatability testing Standard Operating Procedures for details on collecting intermediate and post-treatment samples to minimize volatilization of VOCs, etc.

Sample Storage. Samples will be refrigerated until submitted to the analytical laboratory.

Chains of Custody. All samples submitted to an analytical lab will be accompanied by a chain of custody. The chain of custody will clearly identify the samples and list the required analyses. It will also include a record of who released the samples and to whom they were given.

Submitting Samples. Samples may be picked up by a courier from the analytical laboratory or shipped by PRIMA Environmental to the analytical laboratory. If samples are released to the laboratory's courier, transferring the samples to the laboratory's facility becomes the responsibility of the courier. If samples are shipped by PRIMA Environmental, they will be shipped in one or more coolers, on ice (unless otherwise requested by the analytical laboratory), using an overnight carrier. Samples will be carefully packed to minimize the chance of breakage.

Standard Operating Procedures Soil and Water Preparation

Revised
February 17, 2005

Soil and site water are often homogenized or composited prior to testing by PRIMA Environmental. This Standard Operating Procedure describes the procedures used to prepare soil and groundwater for most treatability tests. *See SOPs for specific treatability tests (eg. Permanganate Treatability Testing) and project specific Scope of Work (SOW) for variations.*

NOTE: All soil and water preparation will be conducted as quickly as practical in order to minimize exposure to air and volatilization of chemicals of concern.

Soil

A soil sample received in multiple containers will be composited and homogenized prior to testing.

1. Empty soil from each sample container into stainless steel bowl.
2. If possible, sieve soil to remove particle greater than 4 mesh (4.76 mm). If sieving is not possible because the sample is clayey or wet, for example, removal large rocks, pebbles and debris by hand. Save the large particles in cases needed later.
3. If the soil contains volatile compounds and if sample size permits, place all sieved soil in a zipper-type plastic bag, close the bag, then homogenize the soil well by turning the bag over in various directions for several minutes or until the soil appears homogenous. Transfer soil to wide-mouth glass jar(s) with minimal headspace. Cap the jar(s).
4. If the soil does not contain volatile compounds or if the volume of soil is too great, return the soil to the stainless steel bowl and mix by hand until of uniform consistency. Transfer to wide mouth glass jar(s) with minimum headspace. Cap the jar(s).
5. Analyze the composited soil per the project SOW.

Site Water

Site water received in multiple containers will be composited prior to use unless otherwise specify in the project SOW.

1. Invert each sample container several times to suspend any solids.
2. Carefully empty each sample containers into a large glass jar. Avoid splashing and "gurgling" in order to minimize potential losses of volatile compounds.
3. Swirl to mix.

4. Redistribute the composited groundwater into the original bottles (if appropriate) or into 1L amber glass bottles. Avoid splashing and “gurgling” in order to minimize potential losses of volatile compounds. Choose container size so that headspace is negligible.
5. Note on the sample containers that the water has been composited.
6. Analyze composited water per the project SOW.

PROJECT EXPERIENCE

PRIMA Environmental has performed tests on soil and water impacted by many compounds of environmental concern. Select examples include

- Investigation of **natural formation** of hexavalent chromium,
- Oxidation of chlorinated solvents by **permanganate**,
- *In situ* stabilization of **hexavalent chromium** in soil and water,
- Destruction of **BTEX, MTBE**, and **chlorinated solvents** using Fenton oxidation,
- Destruction of MTBE and petroleum hydrocarbons using **ozone**,
- Removal of multiple contaminants from barren pond water by **zero-valent iron**,
- Removal of **nitrate** by zero-valent iron and **Sulfur-Modified Iron**,
- Comparison of oxidizing agents for removal of **Aldrin** and **Dieldrin**,
- Comparison of adsorbents for removal of **arsenic**,
- Extraction of **lead** and arsenic from soil under simulated gastric conditions,
- Evaluation of leachate from treated **mine tailings**.

PRIMA Environmental

PRIMA Environmental is an independent laboratory specializing in treatability testing, technology evaluation, custom laboratory work, and scientific consulting services for the environmental community. It was established by Dr. Cindy G. Schreier in **1998** to provide high-quality scientific testing for clients whose projects are too unusual for traditional analytical laboratories.

Dr. Schreier has over fifteen years of hands-on laboratory experience. Before starting PRIMA Environmental, she managed a treatability laboratory for a major, international engineering firm. She earned both her M.S. in Chemistry and Ph.D. in Civil Engineering (Environmental Engineering and Science) from Stanford University.



Cindy G. Schreier, Ph.D.
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Sacramento, CA 95827-3042
(916) 363-8798 ♦ (916) 363-8829 FAX

Email: Iron@PRIMAEnvironmental.com



*Providing site-specific
information so you can make
scientifically sound decisions.*



SOLUTIONS YOU CAN USE

Have you ever wanted to

- Determine which oxidant would work best at your site—without performing an expensive field pilot test?
- Perform a soil extraction using simulated physiological conditions in order to more accurately assess risk?
- Find out which chemical treatments can destroy that “unusual” contaminant at your site?

Were you **unable** to because

- you didn't know what kind of test to perform, or
- you couldn't find a laboratory willing to conduct non-standard tests?

PRIMA Environmental **specializes** in laboratory testing for which standard methods do not exist. After discussing your goals, PRIMA Environmental will **design and perform** tests to address your specific needs, or if you prefer, will follow procedures that you supply.

For more information on how you can benefit from PRIMA Environmental's laboratory and consulting services, **call** Dr. Cindy G. Schreier at (916) 363-8798.

LABORATORY SERVICES

PRIMA Environmental's laboratory services include the following:

- Batch and column bench-scale testing,
- Comparison of treatment options, such as Fenton's reagent, permanganate and ozonation,
- Identification of effective treatments for less commonly encountered contaminants,
- Measurement of rate constants for removal of VOCs by iron walls,
- Measurement of permanganate soil oxidant demand,
- Development of design parameters for pilot tests or full scale implementation,
- Physiologically based soil extractions
- Performance of analyses not having an EPA or other “official” procedure.

Benefits

Laboratory testing can save you time and money by providing site-specific information to support your goals for the site. For example, treatability testing can identify the most cost-effective remediation technology, while physiologically-based soil extractions can help you set a safe clean-up criterion.

CONSULTING SERVICES

PRIMA Environmental also provides consulting services to assist clients in evaluating laboratory data and other scientific information. These services include

- Review of previous treatability studies,
- Scientific review of reports,
- Development of test procedures,
- Literature searches/reviews,
- Technical oversight of innovative remediation technologies,
- Presentation of data and scientific issues to clients, legal counsel, regulatory agencies, stakeholders, students and other interested parties

Benefits

Understanding the science behind your options can help you choose the best methods of managing the environmental issues at your site and help stakeholders accept and support your decisions.



www.PRIMAEnvironmental.com

Appendix D

Fact Sheet and Material Safety Data Sheet (MSDS) for Selected NaMnO₄ Reagent

RemOx® L
ISCO Reagent
CAS Registry No. 10101-50-5
EINECS No. 233-251-1

Fact Sheet

RemOx® L ISCO Reagent has been specifically manufactured for environmental applications such as remediation of soils and associated groundwater. This product can be used to degrade a variety of contaminants such as chlorinated solvents, polyaromatic hydrocarbons, phenolics, organo-pesticides and substituted aromatics. RemOx® L ISCO Reagent is shipped with a Certificate of Analysis (COA).

Product Specifications

Assay, %	39.5 - 41.0 as NaMnO ₄
pH	5.0 - 8.0
Trace Metals	(See Table 1)

Chemical/Physical Data

Formula	NaMnO ₄
Appearance	Dark Purple Solution
Specific Gravity	1.365-1.385
Shelf Life	18 months
Freezing Point	4° F
Solubility in Water	Miscible with water in all proportions.

Material will pass through a 10 micron filter

Applications

RemOx® L ISCO Reagent is used for soil and groundwater remediation by in-situ or ex-situ chemical oxidation and as active agent in subsurface reactive barriers for treatment of:

- Chlorinated Ethenes-PCE, TCE, Vinyl Chloride, etc.
- Phenolics-PCP, p-Cresol, 2,3 Dichlorophenol, etc.
- Polyaromatic Hydrocarbons-Naphthalene, Phenanthrene, Benzo(a)Pyrene, etc.
- TNT, RDX, HMX, etc.
- Various Pesticides

Benefits

- Concentrated liquid form
- More precise dosing of chemical
- Feed equipment is simplified
- Consistent concentration
- High stability

Shipping Containers

5-gallon (20-L) HDPE Jerrican

(UN Specification: UN3H1/Y1.8/100) Made of high-density polyethylene (HDPE). Weighs 3.5 lb (1.6 kg). The net weight is 57 lbs (25.7 kg). The jerrican stands approximately 13.4 in. tall, 9.4 in. wide, and 13.0 in. deep (33.9 cm high, 23.8 cm wide, and 33.0 cm deep).

55-gallon (208.2L) HDPE TightHead Drum

(UN Specification: UN1H1/Y1.9/150) Made of high-density polyethylene (HDPE). Weighs 22 lbs (10 kg). The net weight is 550 lbs (249.5 kg). The drum stands approximately 34.5 in. tall, has an outside diameter of 23.4 in. (89.1 cm tall, OD 59.4 cm).

275-gallon (1041L) IBC (Intermediate Bulk Container)

(UN Specification: UN31HA1/Y1.9/100) They are also marked "MX" for multi-trip IBC Weighs 139 lbs (65 kg). The net weight is 3000 lb (1161 kg). The IBC contains 263 gallons or 995 liters of product. The IBC dimensions are 45.4 in. high, 48 in. long, and 40 in. wide. The IBC has a 2" butterfly valve with NPT threads in bottom sump. (Domestic)

Bulk Shipping - Quantities up to 4000 gallons are available.

Handling and Storage

Like any strong oxidant RemOx® L ISCO Reagent should be handled with care. Protective equipment during handling should include face shields and/or goggles, rubber or plastic gloves, and rubber or plastic apron. If clothing becomes spotted, wash off immediately; spontaneous ignition can occur with cloth or paper. In cases where significant exposure exists use the appropriate NIOSH-MSHA dust or mist respirator is recommended.

Store in accordance with NFPA (National Fire Protection Association) Code 430 requirements for Class II Oxidizers. The product should be stored in a cool, dry area in closed containers. Concrete floors are preferred. Avoid wooden decks. Spillage should be collected and disposed of properly. Contain and dilute spillage to approximately 6% with water, and then reduce with sodium thiosulfate, a bisulfite, or ferrous salt solution. The bisulfite or ferrous salt may require some dilute sulfuric acid (10% w/w) to promote reduction. Neutralize with sodium carbonate to neutral pH, if acid was used. Deposit sludge in an approved landfill or, where permitted, drain into sewer with large quantities of water.

As an oxidant, the product itself is non-combustible, but will accelerate the burning of combustible materials. Therefore, contact with all combustible materials and/or chemicals must be avoided. These include but are not limited to: wood, cloth, organic chemicals, and charcoal. Fires may be controlled and extinguished by using large quantities of water. Refer to the MSDS for more information. Avoid contact with acids, peroxides, sulfites, oxalates, and all other oxidizable inorganic chemicals. During contact with hydrochloric acid, chlorine is liberated.

CARUS CHEMICAL COMPANY

Shipping

RemOx® L ISCO Reagent is classified as an oxidizer for both domestic and international transportation. Liquid permanganate is shipped domestically as Freight Class 70.

Harmonized Code for export: 2841.69.0010

Proper Shipping Name: Permanganates, inorganic, aqueous solution n.o.s (contains permanganate).

Hazard Class: 5.1

Identification Number: UN 3214

Packaging Group: II

Label Requirements: Oxidizer, 5.1

Packaging Requirements: 49 CFR Parts 171 to 180
Sections: 173.152, 173.202, 173.242.

Quantity Limitations: 1 liter net for passenger aircraft or railcar;
5 liters net for cargo aircraft.

Vessel Stowage: D-material must be stowed "on-deck" on a cargo vessel, but is prohibited on a passenger vessel. Other provisions: stow separately from ammonium compounds, hydrogen peroxide, peroxides, super-oxides, cyanide compounds and powdered metal.

Compatibility Information

RemOx® L ISCO Reagent is compatible with many metals and synthetic materials. Natural rubbers and fibers are often incompatible. Solution pH and temperature are also important factors. The material selected for use with liquid permanganate must also be compatible with any kind of acid or alkali being used.

In neutral and alkaline solutions, sodium permanganate is not corrosive to carbon steel and 316 stainless steel. However, chloride corrosion of metals may be accelerated when an oxidant such as liquid permanganate is present in solution. Plastics such as Teflon, polypropylene, HDPE and EPDM are also compatible with liquid permanganate.

Aluminum, zinc, copper, lead, and alloys containing these metals maybe be slightly affected by sodium permanganate. Actual corrosion or compatibility studies should be made under the conditions in which RemOx® L ISCO Reagent will be used prior to use.

Table 1: Trace Metal Content and Specifications

	Typical Analysis (mg/kg)	Specification (mg/kg)	DL* (mg/kg)	Element	Typical Analysis (mg/kg)	Specification (mg/kg)	DL* (mg/kg)
Ag	0.04	0.15	0.034	Fe	0.05	2.00	0.053
Al	0.74	2.00	0.24	Hg	BDL	0.03	0.003
As	0.01	4.00	0.006	Ni	BDL	0.10	0.030
Ba	2.16	5.00	0.016	Pb	BDL	0.70	0.16
Be	BDL	0.50	0.08	Sb	BDL	0.70	0.16
Cd	0.02	0.10	0.016	Se	0.006	0.50	0.0003
Cr	1.54	5.00	0.031	Tl	BDL	3.50	0.8
Cu	BDL	0.10	0.022	Zn	0.026	0.40	0.011

*DL=Detection Limit

Carus Chemical Company

During its 90-year history, Carus' ongoing emphasis on research and development, technical support, and customer service has enabled the company to become the world leader in permanganate, manganese, oxidation, and base-metal catalyst technologies.



Carus Chemical Company

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Form #RX1603



RemOx® L ISCO Reagent

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Section 1 Chemical Product and Company Identification

PRODUCT NAME: RemOx® L ISCO Reagent	Revision Date: January 2006
TRADE NAME: RemOx® L ISCO Reagent	

USES OF SUBSTANCE: RemOx® L ISCO Reagent is a liquid oxidant recommended for in-situ and ex-situ remediation of sites that require a strong oxidant.

COMPANY NAME (Europe): CARUS NALON S.L. COMPANY NAME (US): CARUS CHEMICAL COMPANY	COMPANY ADDRESS: Carus Nalon S.L. Barrio Nalon, s/n 33100 Trubia-Oviedo Espana, Spain INFORMATION: (34) 985-785-513 (34) 985-785-513 www.caruseurope.com (Web) carus@carusnalon.com (Email)
	EMERGENCY TELEPHONE: (34) 985-785-513 COMPANY ADDRESS: 315 Fifth Street Peru, IL 61354, USA INFORMATION: (815)-223-1500 www.caruschem.com (Web) salesmkt@caruschem.com (Email)
	EMERGENCY TELEPHONE: (800) 435 -6856 (USA) (800) 424-9300 (CHEMTREC, USA) (815-223-1500 (Other countries)

Section 2 Hazardous Ingredients

Material or Component	CAS No.	%	Hazard Data
Sodium Permanganate	10101-50-5	40	PEL/C 5 mg Mn per cubic meter of air TLV-TWA 0.2 mg Mn per cubic meter of air
HAZARD SYMBOLS:			
<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  O </div> <div style="text-align: center;">  Xn </div> <div style="text-align: center;">  N </div> </div>			
RISK PHRASES:			
8 Contact with combustibles may cause fire. 22 Harmful if swallowed. 50/53 Very toxic to aquatic organisms, may cause long-term effects in the aquatic environment.			
SAFETY PHRASES:			
17 Keep away from combustible materials. 24/25 Avoid contact with skin and eyes. 26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice			



RemOx® L ISCO Reagent

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Section 3 Hazards Identification

1. Eye Contact
RemOx® L ISCO Reagent is damaging to eye tissue on contact. It may cause burns that result in damage to the eye.
2. Skin Contact
Momentary contact of solution at room temperature may be irritating to the skin, leaving brown stains. Prolonged contact is damaging to the skin.
3. Inhalation
Acute inhalation toxicity data are not available. However, airborne concentrations of RemOx® L ISCO Reagent in the form of mist may cause irritation to the respiratory tract.
4. Ingestion
RemOx® L ISCO Reagent if swallowed, may cause burns to mucous membranes of the mouth, throat, esophagus, and stomach.

Section 4 First Aid Measures

1. Eyes
Immediately flush eyes with large amounts of water for at least 15 minutes holding lids apart to ensure flushing of the entire surface. Do not attempt to neutralize chemically. Seek medical attention immediately. Note to physician: Decomposition products are alkaline.
2. Skin
Immediately wash contaminated areas with water. Remove contaminated clothing and footwear. (Caution: Solution may ignite certain textiles). Wash clothing and decontaminate footwear before reuse. Seek medical attention immediately if irritation is severe and persistent.
3. Inhalation
Remove person from contaminated area to fresh air. If breathing has stopped, resuscitate and administer oxygen if readily available. Seek medical attention immediately.
4. Ingestion
Never give anything by mouth to an unconscious or convulsing person. If person is conscious, give large quantities of water or milk. Seek medical attention immediately.

Section 5 Fire Fighting Measures

NFPA* HAZARD SIGNS:

Health Hazard	1	=	Materials which under fire conditions would give off irritating combustion products. (less than 1 hour exposure)	Materials which on the skin could cause irritation.
Flammability Hazard	0	=	Materials that will not burn.	
Reactivity Hazard	0	=	Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.	
Special Hazard	OX	=	Oxidizer	

*National Fire Protection Association 704

FIRST RESPONDERS:

Wear protective gloves, boots, goggles, and respirator. In case of fire, wear positive pressure breathing apparatus. Approach incident with caution. Use 2004 Emergency Response Guidebook (U.S. DOT RSPA, TC and STC). Guide No. 140. (<http://hazmat.dot.gov/pubs/erg2004/erg2004.pdf>).



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FLASHPOINT	None
FLAMMABLE OR EXPLOSIVE LIMITS	Lower: Nonflammable Upper: Nonflammable
EXTINGUISHING MEDIA	Use large quantities of water. Water will turn pink to purple if in contact with RemOx® L ISCO Reagent. Dike to contain. Do not use dry chemicals, CO ₂ Halon® or foams.
SPECIAL FIREFIGHTING PROCEDURES	If material is involved in fire, flood with water. Cool all affected containers with large quantities of water. Apply water from as far as a distance as possible. Wear self-contained breathing apparatus and full protective clothing.
UNUSUAL FIRE AND EXPLOSION	Powerful oxidizing material. May decompose spontaneously if exposed to heat (135°C/275°F). May be explosive in contact with certain other chemicals (Section 10). May react violently with finely divided and readily oxidizable substances. Increases burning rate of combustible material. May ignite wood and cloth.

Section 6 Accidental Release Measures

PERSONAL PRECAUTIONS

Personnel should wear protective clothing suitable for the task. Remove all ignition sources and incompatible materials before attempting clean up.

ENVIRONMENTAL PRECAUTIONS:

Do not flush into sanitary sewer system or surface water. If accidental release into the environment occurs, inform the responsible authorities. Keep the product away from drains, sewers, surface and ground water and soil.

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

Contain spill by collecting the liquid in a pit or holding behind a dam (sand or soil). Dilute to approximately 6% with water, and then reduce with sodium thiosulfate, a bisulfite or ferrous salt solution. The bisulfite or ferrous salt may require some dilute sulfuric acid (10% w/w) to promote reduction. Neutralize with sodium carbonate to neutral pH, if acid was used. Decant or filter and deposit sludge in approved landfill. Where permitted, the sludge may be drained into sewer with large quantities of water. To clean contaminated floors, flush with abundant quantities of water into sewer, if permitted by federal, state, and local regulations. If not, collect water and treat as above.



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Section 7 Handling and Storage

WORK/HYGIENIC PRACTICES

Wash hands thoroughly with soap and water after handling RemOx® L ISCO Reagent. Do not eat, drink or smoke when working with RemOx® L ISCO Reagent. Wear proper protective equipment. Remove clothing, if it becomes contaminated.

VENTILATION REQUIREMENTS

Provide sufficient mechanical and/or local exhaust to maintain exposure below the TLV/TWA.

CONDITIONS FOR SAFE STORAGE

Store in accordance with NFPA 430 requirements for Class II oxidizers. Protect containers from physical damage. Store in a cool, dry area in closed containers. Segregate from acids, peroxides, formaldehyde, and all combustible, organic, or easily oxidizable materials including antifreeze and hydraulic fluid.

Section 8 Exposure Controls and Personal Protection

RESPIRATORY PROTECTION

In cases where overexposure to mist may occur, the use of an approved NIOSH-MSHA mist respirator or an air supplied respirator is advised. Engineering or administrative controls should be implemented to control mist.

EYE

Faceshield, goggles, or safety glasses with side shields should be worn. Provide eyewash in working area.

GLOVES

Rubber or plastic gloves should be worn.

OTHER PROTECTIVE EQUIPMENT

Normal work clothing covering arms and legs, and rubber, or plastic apron should be worn. Caution: If clothing becomes contaminated, wash off immediately. Spontaneous ignition may occur with cloth or paper.

Section 9 Physical and Chemical Properties

APPEARANCE AND ODOR	Dark purple solution, odorless
BOILING POINT, 760 mm Hg	105 °C
VAPOR PRESSURE (mm Hg)	760 mm at 105°C
SOLUBILITY IN WATER % BY SOLUTION	Miscible in all proportions
PERCENT VOLATILE BY VOLUME	61% (as water)
EVAPORATION RATE	Same as water
FREEZING POINT	-15.0 °C
SPECIFIC GRAVITY	1.36-1.39
pH	5-9
OXIDIZING PROPERTIES	Strong oxidizer. May ignite wood and cloth.
EXPLOSIVE PROPERTIES	Explosive in contact with sulfuric acid or peroxides, or



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readily oxidizable substances.

Section 10 Stability and Reactivity

STABILITY	Under normal conditions, the material is stable.
CONDITIONS TO AVOID could	Contact with incompatible materials or heat (135°C / 275°F) result in violent exothermic chemical reaction.
INCOMPATIBLE MATERIALS	Acids, peroxides, formaldehyde, antifreeze, hydraulic fluids, and all combustible organic or readily oxidizable materials, including metal powders. With hydrochloric acid, toxic chlorine gas is liberated.
HAZARDOUS DECOMPOSITION PRODUCTS	When involved in a fire, liquid permanganate may form corrosive fumes.
CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION	Material is not known to polymerize.

Section 11 Toxicological Information

SODIUM PERMANGANATE: Acute oral LD₅₀ not known.

1. Acute toxicity

Irritating to body tissue with which it comes into contact. No acute toxicity data is available for sodium permanganate. Toxicity is expected to be similar to that of potassium permanganate. The toxicity data for potassium permanganate is given below:

Ingestion:

LD 50 oral rat: 780 mg/kg male (14 days); 525 mg/kg female (14 days).

Harmful if swallowed. ALD: 10g. Ingestion may cause nausea, vomiting, sore throat, stomach-ache and eventually lead to a perforation of the intestine. Liver and kidney injuries may occur.

Skin contact:

LD 50 dermal no data available.

The product may be absorbed into the body through the skin. Major effects of exposure: severe irritation, brown staining of skin.

Inhalation:

LC 50 inhal. no data available.

The product may be absorbed into the body by inhalation. Major effects of exposure: respiratory disorder, cough.

2. Chronic toxicity

No known cases of chronic poisoning due to permanganates have been reported. Prolonged exposure, usually over many years, to heavy concentrations of manganese oxides in the form of dust and fumes may lead to



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3. Carcinogenicity

4. Medical Conditions Generally Aggravated by Exposure

Sodium permanganate solution will cause further irritation of tissue, open wounds, burns or mucous membranes.

Entry to the Environment

Bioconcentration Potential

Aquatic Toxicity

No data.

Waste Disposal

RemOx® L ISCO Reagent, once it becomes a waste, is considered a D001 hazardous (ignitable) waste. For disposal of RemOx® L ISCO Reagent solutions, follow procedures in Section 6 and deactivate the permanganate to insoluble manganese dioxide. Dispose of it in a permitted landfill. Contact Carus Chemical Company for additional recommendations.

Section 14 Transport Information

USA (land, D.O.T.)	<table border="0"> <tr> <td>Proper Shipping Name:</td><td>49 CFR172.101 Permanganates, inorganic, aqueous</td></tr> <tr> <td>Hazard Class:</td><td>49 CFR172.101....Oxidizer</td></tr> <tr> <td>ID Number:</td><td>49 CFR172.101....UN 3214</td></tr> <tr> <td>Packing Group:</td><td>49 CFR172.101....II</td></tr> <tr> <td>Division:</td><td>49 CFR172.101....5.1</td></tr> </table>	Proper Shipping Name:	49 CFR172.101 Permanganates, inorganic, aqueous	Hazard Class:	49 CFR172.101....Oxidizer	ID Number:	49 CFR172.101....UN 3214	Packing Group:	49 CFR172.101....II	Division:	49 CFR172.101....5.1
Proper Shipping Name:	49 CFR172.101 Permanganates, inorganic, aqueous										
Hazard Class:	49 CFR172.101....Oxidizer										
ID Number:	49 CFR172.101....UN 3214										
Packing Group:	49 CFR172.101....II										
Division:	49 CFR172.101....5.1										
European Labeling in accordance Road/Rail Transport (ADR/RID)	<table border="0"> <tr> <td>ID Number:</td><td>UN 3214</td></tr> <tr> <td>ADR/RID Class</td><td>5.1</td></tr> <tr> <td>Description of Goods:</td><td>Permanganates, inorganic, aqueous solution, n.o.s (contains sodium permanganate)</td></tr> <tr> <td>Hazard Identification No.</td><td>50</td></tr> </table>	ID Number:	UN 3214	ADR/RID Class	5.1	Description of Goods:	Permanganates, inorganic, aqueous solution, n.o.s (contains sodium permanganate)	Hazard Identification No.	50		
ID Number:	UN 3214										
ADR/RID Class	5.1										
Description of Goods:	Permanganates, inorganic, aqueous solution, n.o.s (contains sodium permanganate)										
Hazard Identification No.	50										
European Labeling in accordance with EC directive (Water, I.M.O.)	<table border="0"> <tr> <td>Proper Shipping Name:</td><td>Permanganates, inorganic, aqueous solution, n.o.s (contains sodium permanganate)</td></tr> <tr> <td>Hazard Class:</td><td>Oxidizer</td></tr> <tr> <td>ID Number:</td><td>UN 3214</td></tr> </table>	Proper Shipping Name:	Permanganates, inorganic, aqueous solution, n.o.s (contains sodium permanganate)	Hazard Class:	Oxidizer	ID Number:	UN 3214				
Proper Shipping Name:	Permanganates, inorganic, aqueous solution, n.o.s (contains sodium permanganate)										
Hazard Class:	Oxidizer										
ID Number:	UN 3214										



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	Packing Group: II Division: 5.1 Marine Pollutant: No
European Labeling in accordance with EC directive (Air, I.C.A.O.)	Proper Shipping Name: Permanganates, inorganic, aqueous solution, n.o.s (contains sodium permanganate) Hazard Class: Oxidizer ID Number: UN 3214 Packing Group: II Division: 5.1

Section 15 Regulatory Information (Sodium Permanganate)

TSCA	Listed in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory.
CERCLA	Not listed.
RCRA	Oxidizers such as RemOx® L ISCO Reagent solution meet the criteria of ignitable waste. 40 CFR 261.21.
SARA TITLE III Information	
Section 302/303	Extremely hazardous substance: Not listed
Section 311/312	Hazard categories: Fire, acute and chronic toxicity.
Section 313	RemOx® L ISCO Reagent contains 40% manganese compounds as part of the chemical and is subject to the reporting requirements of Section 313 of Title III, Superfund Amendments and Reauthorization Act of 1986 and 40 CFR 372.
FOREIGN LIST	Canadian Non-Domestic Substance List , EINECS

Section 16 Other Information

NIOSH	National Institute for Occupational Safety and Health
MSHA	Mine Safety and Health Administration
OSHA	Occupational Safety and Health Administration
NTP	National Toxicology Program
IARC	International Agency for Research on Cancer
PEL	Permissible Exposure Limit
C	Ceiling Exposure Limit
TLV-TWA	Threshold Limit Value-Time Weighted Average
CAS	Chemical Abstract Service
EINECS	Inventory of Existing Chemical Substances (European)

Chithambarathanu Pillai (S.O.F.)
January 2006

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handling, and use of the product are beyond the control of Carus Chemical Company, and shall be the sole responsibility of the holder or user of the product.

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Appendix E

Input Variables and Calculations for Equivalent NaMnO_4 Loading Rate

APPENDIX E

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SODIUM PERMANGANATE OXIDANT DEMAND CALCULATIONS Burlington Northern Livingston Shop Complex

Equation Number	Parameter	Unit	Assumed or Calculated Value
1	Length	feet	30
2	Width	feet	30
3	Area	square feet	900
4	Thickness	feet	20
5	Total volume	cubic yard	667
6	Effective porosity	percent	25
7	Total "mobile" groundwater pore volume	gallon	33,660
8	Average tetrachloroethene (PCE) concentration	milligram/Liter	2
9	Mass of PCE	pound	0.5612
10	Assumed soil oxidant demand (SOD) loading	gram KMnO_4 per kilogram soil	0.5
11	Assumed SOD loading - unit conversion	pound KMnO_4 per cubic yard	1.49
12	SOD	pound KMnO_4	990
13	Average stoichiometric demand	pound KMnO_4 per pound PCE	1.3
14	PCE oxidant demand	pound KMnO_4	0.7296
15	Theoretical total SOD as NaMnO_4	pound NaMnO_4	890
16	<u>Mass of 40 percent NaMnO_4 solution</u>	<u>pound NaMnO_4</u>	2,200
17	<u>Volume of 40 percent NaMnO_4 solution (specific gravity 1.391)</u>	<u>gallon</u>	190
18	<u>Desired Radius of Influence (ROI) at each well</u>	<u>feet</u>	3
19	<u>Total injection volume required for 3-ft ROI, times 4 wells</u>	<u>gallons</u>	4,150
20	<u>Volume dilution water required</u>	<u>gallons</u>	3,960
21	Injection concentration NaMnO_4	percent by weight	2.5
22	Pore volume displacement	percent	12

SODIUM PERMANGANATE OXIDANT DEMAND CALCULATIONS

Burlington Northern Livingston Shop Complex

Notes:

- 1 Length - designated pilot study area dimension.
- 2 Width - designated pilot study area dimension.
- 3 Area = length * width = 30 feet * 30 feet = 900 square feet.
- 4 Presumed Treatment Zone Thickness = 20 feet
- 5 Total volume = area * depth * conversion.
- 6 Effective porosity = 25 percent as determined by previously conducted work.
- 7 Total "mobile" groundwater pore volume = area * thickness * effective porosity * conversion factors.
- 8 Maximum assumed average PCE concentration.
- 9 Mass of PCE = pore volume * average PCE concentration * conversion factors.
- 10 Assumed SOD loading rate = 0.5 gram KMnO_4 per kilogram soil (typical SOD value for coarse sand).
- 11 SOD (pound per cubic yard) = SOD * soil density * conversion factors.
- 12 SOD = SOD (pound per cubic yard) * cubic yards.
- 13 Average stoichiometric demand = 1.3 pounds of KMnO_4 per pound of PCE (based on reaction stoichiometry).
- 14 PCE oxidant demand = mass of PCE * average stoichiometric demand.
- 15 Theoretical total SOD as NaMnO_4 = (SOD + PCE oxidant demand) * (molecular weights of NaMnO_4 / KMnO_4).
- 16 Mass of 40 percent NaMnO_4 solution = theoretical total SOD / (percent solution).
- 17 Volume of 40 percent solution = pounds of 40 percent NaMnO_4 solution / (8.34 pounds/gallon water * specific gravity of 40 percent NaMnO_4 solution = 1.391).
- 18 Radius of influence selected at 3 feet to provide better inundation of treatment zone
- 19 Total injection volume to reach 3-ft ROI: $V = \pi r^2 * \text{thickness} * \text{porosity} * \text{number of wells} = (3.14) * (3^2) * (20) * (0.25) * (7.48 \text{ gallons/cubic foot}) * (4 \text{ wells})$
- 20 Dilution water volume = Total injection volume – Volume 40 percent NaMnO_4 solution
- 21 Injection Concentration of NaMnO_4 solution = Total SOD as NaMnO_4 / Total volume = (890 pounds) / (4,150 gallons * 8.34 pounds/gallon)
- 22 Pore volume displacement = (total injection volume) / total pore volume = 4,150 gallons / 33,660 gallons).

KMnO_4 - potassium permanganate

NaMnO_4 - sodium permanganate

Appendix F

Well Logs for L-88-11, 89-3, and 90-6

RETECREMEDICATION
TECHNOLOGIES INC**BORING LOG**BORING L-88-11
SHEET 1 OF 1

PROJECT BN Livingston		CONTRACTOR: Hillman Drilling	MONUMENT
PROJECT * C86-054-510		DRILLER Ed Hillman/Todd	RISER schedule 40 PVC
LOCATION W of Maintenance Shop ***		RIG TYPE Schramm T-64	SCREEN 0.020 slot PVC 29' to 19'
TOTAL DEPTH 29'		METHOD air rotary/cas driver	FILTER PACK silica* 29' to 16'10"
DATE 2-24-88		CASING ID 8"to30'	SEAL volclay** 16'10" to 15'8"
STARTED 0820	COMPLETED 1430	BORING ID	GROUT
LOGGED BY LDZ		BIT TYPE	GROUND ELEV

SAMPLE TYPE AND NUMBER	BLOWS PER 6 IN.	DEPTH RANGE	% REC	DEPTH FEET	SAMPLE DESCRIPTION CLASSIFICATION SCHEME	USCS
				5	surface is gravels <1" to ~3" with some bigger sandy gravels, brown, some fines	GW
				10		
				15	sandy gravels, brown, silt-clay (60% sand and gravel/40% fines)	GM
				20	18-19' hit water	
				25		
				30	27 1/2' clay layer (oil in clay) CL 29' shale bedrock (oil shale with oily streaks coming up in the mud/water mixture)	
					TD - 29'	

GROUNDWATER DEPTH(FT) 18.15' DATE/TIME 2/26 1444

REMARKS: * granusil grade 16 ** 1/4" tablets *** F & Gallatin Streets

ENVIROCON, INC.

Well Log

Well Drilled: 89-3

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Project: Livingston/BN

Owner: BN

Location: Livingston, MT

Project No: 140101

Date Drilled: 1/20/90

Total Depth: 35'

Diameter: 6"

Surface Elev: 4493.04

Elevation TOC: 4493.04

Initial WL:

Screen Dia: 2"

Length: 20'

Slot Size: 0.02

Casing Dia: 2"

Length: 14'

Type: Sch 40 PVC

Drilling Co: Dan O'Keefe

Drilling Method: Air Rotary

Driller: Dan O'Keefe

Logged By: John Mills

Sketch Map

Notes:

Depth (ft)	Well Construction	PID Reading	Sample Number	Graphic Log	Description/Soil Classification (Color, Texture, Structures)
5		5' HS = 37.8			0' - 2/3' Concrete
10		10' HS = 12.1			2/3' - 7' Black, sticky clay 7' - 9' Grey-tan, medium-grain, cobbly sand
15		15' HS = 9.2			9' - 20' Sandy gravel Below 18' Damp
20		20' HS = 78.0	20' 140101-SO-014		20' - 24' Wet, coarse gravel
25		25' HS = 173			24' - 26' Damp, coarse, sandy gravel 26' - 32' Wet, sandy gravel - made ~5 gallons of water
30		30' HS = 15			32' - 34' Dark brown, sticky clay Bedrock at 34' - Dark grey, fine-grain sandstone
35		35' HS = 0.0			TD = 35'
40					
45					Developed on 2/21/90, 150 gallons of water pumped

ENVIROCON, INC.

Well Log

Well Drilled: 90 -6

Page 1 of 1

Project: Livingston/BN Owner: BN

Location: Livingston, MT Project No: 140101

Date Drilled: 11/19/90 Total Depth: 36' Diameter: 6"

Surface Elev: Elevation TOC: 4495.10 Initial WL:

Screen Dia: 2" Length: 20' Slot Size: 0.01

Casing Dia: 2" Length: 13' Type: Sch 40 PVC

Drilling Co: Dan O'Keefe Drilling Method: Air Rotary

Driller: Doug Beck Logged By: Crowell Herrick
Wayde Haefs

Sketch Map

Notes:

Depth (ft)	Well Construction	PID Reading	Sample Number	Graphic Log	Description/Soil Classification (Color, Texture, Structures)
5					0' - 3' Black cinder, slightly damp 3' - 29' Dry, sandy gravel
10					10' Dry, coarse, sandy gravel
15					
20					20' Dry, coarse, sandy gravel with some fine sand
25					21' Coarse, damp, sandy gravel 24' Moist
30					28' Made water 29' - 34' Gravel
35					34' Blue shale 35' - 36' Dark brown, moist sand 36' Bedrock - shale TD = 36'
40					
45					

Appendix G

Task-Specific Health and Safety Plan

Date Approved by Kennedy/Jenks Consultants Regional Safety Supervisor:

Task Site Safety Officer: Matthew Gibson Phone: 406-728-1122

Task Field Site Safety Officer: Matthew Gibson Phone: 406-240-5456 (cell)

Task Description:

Task F addresses monitoring and cleanup of chlorinated volatile organic compounds (VOCs) in the alluvial aquifer. As part of Task F Stage I – Part 2 remedial action (RA) activities chemical oxidation using sodium permanganate will be pilot tested. New boreholes will be advanced and new groundwater monitoring wells will be installed and monitored during the duration of the pilot test. The chemical oxidation test will involve injecting diluted sodium permanganate solution into the unconfined alluvial aquifer.

The pilot test involves advancing borings and constructing monitoring wells using conventional drilling techniques, collecting groundwater samples from the monitoring wells, operating/maintaining the injection system, and injecting a diluted sodium permanganate solution into soil borings using low-pressure procedures, partially described in the following documents:

- *Final Facility-Wide Sampling and Analysis Plan (SAP)* dated March 2006
- *Task F Stage I – Part 2 Pilot Test Work Plan for VOC-Containing Alluvial Aquifer Groundwater* dated June 2008.

Additional health and safety procedures are explained herein. Field work performed during the pilot test will adhere to safety protocols specified in the *Facility-Wide Health and Safety Plan (Revision No. 3)* (HASP) dated May 2008.

Task-specific health and safety protocols, and additional health and safety protocols and/or deviations from the *Facility-Wide Health and Safety Plan (Revision No. 3)*, if applicable, are outlined in this task-specific HASP.

Summary Information					
Activity	Approx. Start Date	Approx. Duration (Days)	Field Personnel	CPR	First Aid
Construction and development of groundwater monitoring wells.	TBD	4 weeks	Matt Gibson John Lee Dean Malte	X X X	X X X
Overseeing advancement of soil borings and injection of sodium permanganate.	TBD	3 weeks	Nic Winslow Matt Gibson John Lee TBD	X X X	X X X
Groundwater sampling and analysis	TBD	6 months	Robert Huebner David Johnson Matt Gibson John Lee TBD	X X X X	X X X X

HAZWOPER and BNSF Safety Training:

☐ No ☒ Yes Field personnel 40-hour and 8-hour HAZWOPER trained.

Field personnel to wear a photographic identification badge and carry proof of current BNSF training when working at the Livingston railyard.

Applicable Sampling and Analysis Plan (SAP) and Standard Operating Guidelines (SOGs):

1. *Final Facility-Wide Sampling and Analysis Plan*
2. SOG-1, -2, -3, -4A, -4B, -5, -7, -8, -12, -13, -14, -15, -16 (Appendix A of *Final Facility-Wide Sampling and Analysis Plan*)
3. Task-specific SAP in *Task F Stage 1 – Part 2 Pilot Test Work Plan for VOC-Containing Alluvial Aquifer Groundwater*, Section 6.0.

Study Area:

The treatment area includes the area in the vicinity of the former Electric Shop.

Locations of pilot test areas and new wells to be constructed and sampled are shown on Figure 3

Task involves work within 25 feet of track:

☐ No ☒ Yes

If yes, describe means of work clearance and track control:

If work is to be performed within 25 feet of track, Montana Rail Link (MRL) will be notified that a flagger will need to be present at the work area. The flagger will oversee worker safety at the work area.

Health and Safety Risks:

Potential exposure to VOCs in soils and groundwater during drilling (well installation and boring advancement) and sampling procedures. Potential exposure to sodium permanganate, an oxidizer, during handling, mixing, and injection processes. Use caution for potential presence of black widow spiders in wellhead enclosures.

Physical Hazards:

Hazards associated with operating a drilling rig (noise, dust, overhead equipment falling, high-pressure pneumatic lines), underground utilities, equipment hauling, traffic control, and slip and trip. Potential hazards associated with injecting a pressurized liquid. Potential electric hazards associated with operating.

Potential Chemical Hazards:

Chemicals of Concern	TWA-PEL/TLV in parts per million (ppm)
Tetrachloroethene	100 ppm / 25 ppm
Trichloroethene	100 ppm / 25 ppm
Cis-1,2-Dichloroethene	200 ppm / 25 ppm
Vinyl chloride	1 ppm / 1 ppm
Chlorobenzene	75 ppm / 75 ppm
1,4-Dichlorobenzene	75 ppm / 10 ppm
Sodium Permanganate	Not established

Personal Protective Equipment (PPE):

☒ Initial–Level D: Hard hat, boots (steel-toe and shank), safety glasses (with side shields), orange-reflective vest, and hearing protection as needed when at Livingston railyard and during drilling activities.

List additional equipment (e.g., boot covers, Tyvek® coveralls, etc.): Coveralls and latex/chemical resistant gloves, as necessary.

☐ Upgrade–Level C: All of above plus half-face respirator with _____ cartridges

Personal Protective Equipment (PPE) continued:

☒ Other: (describe): Wear chemical resistant overalls, nitrile gloves and full-face splash guard when working with sodium permanganate feed system. Provide an eye wash kit with two bottles, 1-liter each of buffered eyewash solution at chemical feed/mixing tank area.

Safety Measures and Monitoring:

Follow *Facility-Wide Health and Safety Plan (Revision No. 3)* guidance. Do not enter any areas not intended for normal occupancy (e.g., confined spaces).

Criteria for upgrading PPE (list threshold values in breathing zones, or other triggers for upgrading PPE): Withdraw from area and re-assess PPE requirements if there are noticeable odors in work area.

Work Zones:

Work zones will be established during construction of groundwater monitoring wells, construction and outfitting of injection components, and advancement of soil boring and injection of sodium permanganate into the soil borings. No special work zones will be established around the wellhead for groundwater sampling. All field personnel (including subcontractors) must check in/check out with site safety officer (SSO) or field site safety officer (FSSO) on a daily basis.

Other Work Requirements:

Work only in areas with proper illumination or bring sufficient lighting to assess area for hazards.

Community Protection Measures:

Activities associated with the pilot tests will be conducted on the railroad property. Therefore, no community protection measures are warranted. If necessary, access to the area will be cordoned off with flagging and/or fences/barricades. Assure that field activities do not present a hazard to traffic movement. Limit access to chemical area. Label chemical feed and mixing tank with contents, concentration, and National Fire Protection Association hazard diamond. Per Material Safety Data Sheet (MSDS) – Health =1, Flammability = 0, Reactivity = 0, Special = Ox (oxidizer).

Task-Specific Training or Medical Surveillance Requirements:

Review MSDSs for all chemicals with field personnel before initiating work with chemicals.

Task-Specific Hazardous Materials:

The following compounds may be used in association with pilot tests associated with Task F:

- Zinc acetate (sample preservative for samples collected for laboratory sulfide analysis)
- Hydrochloric acid (sample preservative for samples collected for laboratory VOC analysis)
- Ferrous iron (reagent used in Hach Kits)
- Sodium permanganate (reagent for injection for the pilot test)

Task-Specific Decontamination Procedures:

If accidentally exposed to chemicals, flush skin with water for 5 minutes. If chemicals get in eyes, flush with eyewash, then water, and seek medical attention.

Task-Specific Contact Telephone Numbers:

1. Matthew Gibson (406) 728-1122
2. See *Facility-Wide Health and Safety Plan (Revision No. 3)* (Table 3) for additional emergency contact information

Task-Specific Coordination Requirements with BNSF and MRL:

Submit MSDSs for chemicals to BNSF and MRL.

Schedule pilot test activities with MRL prior to beginning activity.

Task-Specific Requirements from the Facility-Wide HASP:

Follow all applicable requirements of *Facility-Wide Health and Safety Plan (Revision No. 3)*.

Task-Specific Deviations from Facility-Wide HASP:

None

Emergency Response (Contingency) Plan:

See *Facility-Wide Health and Safety Plan (Revision No. 3)* (Section 7.0)

Hazardous Material Used for Task (Attach MSDSs and Submit to BNSF and MRL):

See *Facility-Wide Health and Safety Plan (Revision No. 3)* (Appendix A – Hazard Communication and Material Safety Data Sheets).

The following compounds may be used in association with pilot test associated with Task F:

- Zinc acetate (sample preservative for samples collected for laboratory sulfide analysis)
- Hydrochloric acid (sample preservative for samples collected for laboratory VOC analysis)
- Ferrous iron (reagent used in Hach Kits)
- Sodium permanganate (reagent for injection for the pilot test)

MSDSs for these compounds are attached to this task-specific HASP.

Map and Directions to Hospital:

See attached figure.

SIGNATURES**Task Manager:**

Ty Schreiner (253) 874-0555

Project Manager:

John Norris (253) 874-0555

Cell (253) 905-3832

Site Safety Officer:

Matthew Gibson (406) 728-1122

Regional Safety Supervisor:

John Jindra (253) 942-3466

ATTACHMENTS

Attachment 1 – Locations of Field Activities

- Figure 3 from *Task F Stage 1 – Part 2 Pilot Test Work Plan for VOC-Containing Alluvial Aquifer Groundwater*

Attachment 2 – Route to Hospital

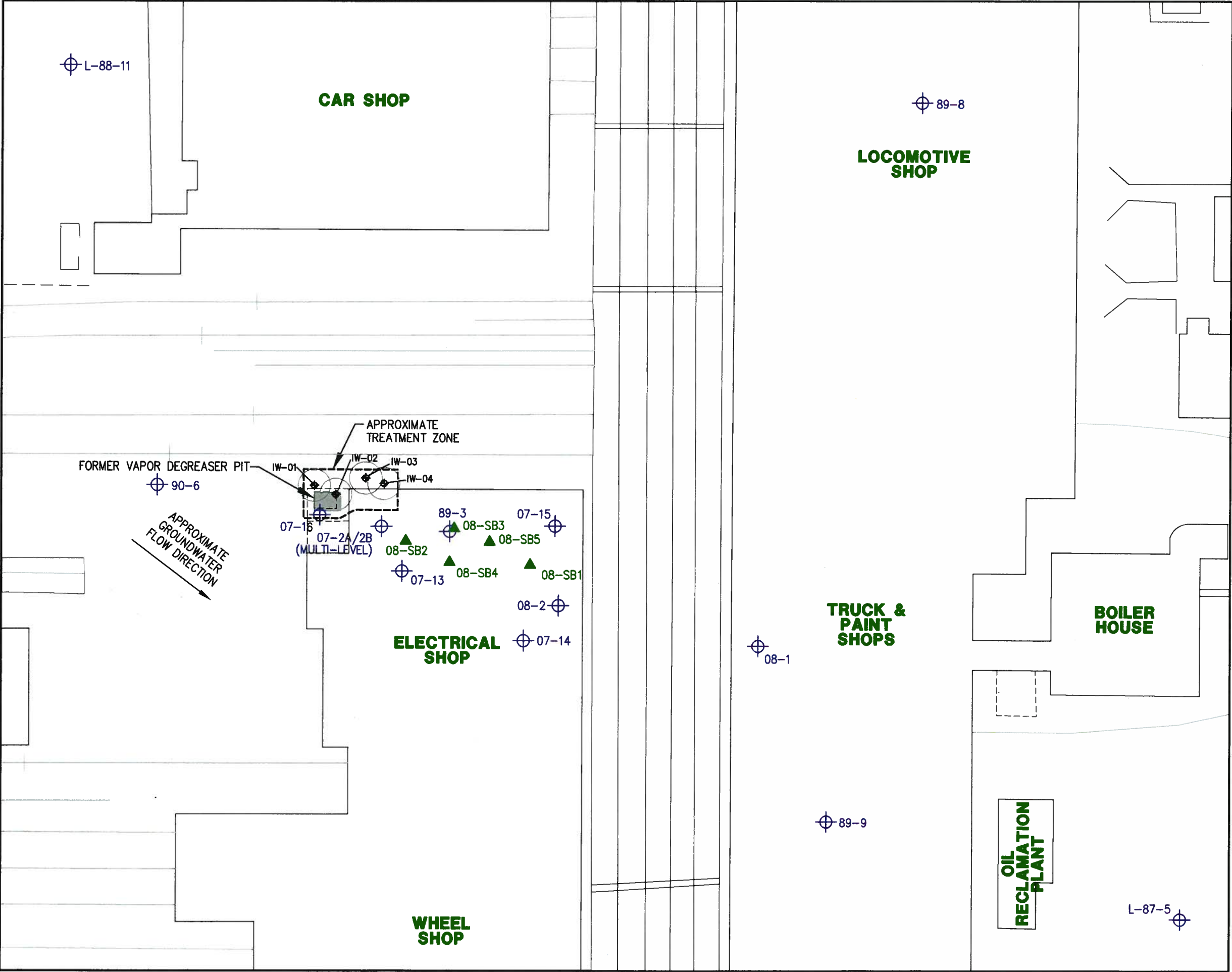
- Hospital Location and Route Map – Figure 3 from *Facility-Wide Health and Safety Plan Revision No. 3)*

Attachment 3 – Material Safety Data Sheets

- MSDS for zinc acetate
- MSDS for ferrous iron reagent
- MSDS for hydrochloric acid
- MSDS for sodium permanganate

Attachment 1

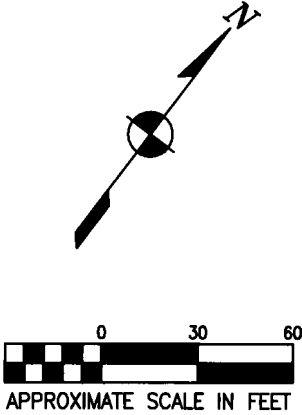
Locations of Field Activities



LEGEND

- IW-01 PROPOSED PERMANGANATE INJECTION BORING
- ESTIMATED RADIUS OF INFLUENCE = 10 FEET
- 89-3 EXISTING MONITORING WELL LOCATION
- 08-SB4 SOIL BORING LOCATION

NOTE:
1) ALL LOCATIONS ARE APPROXIMATE



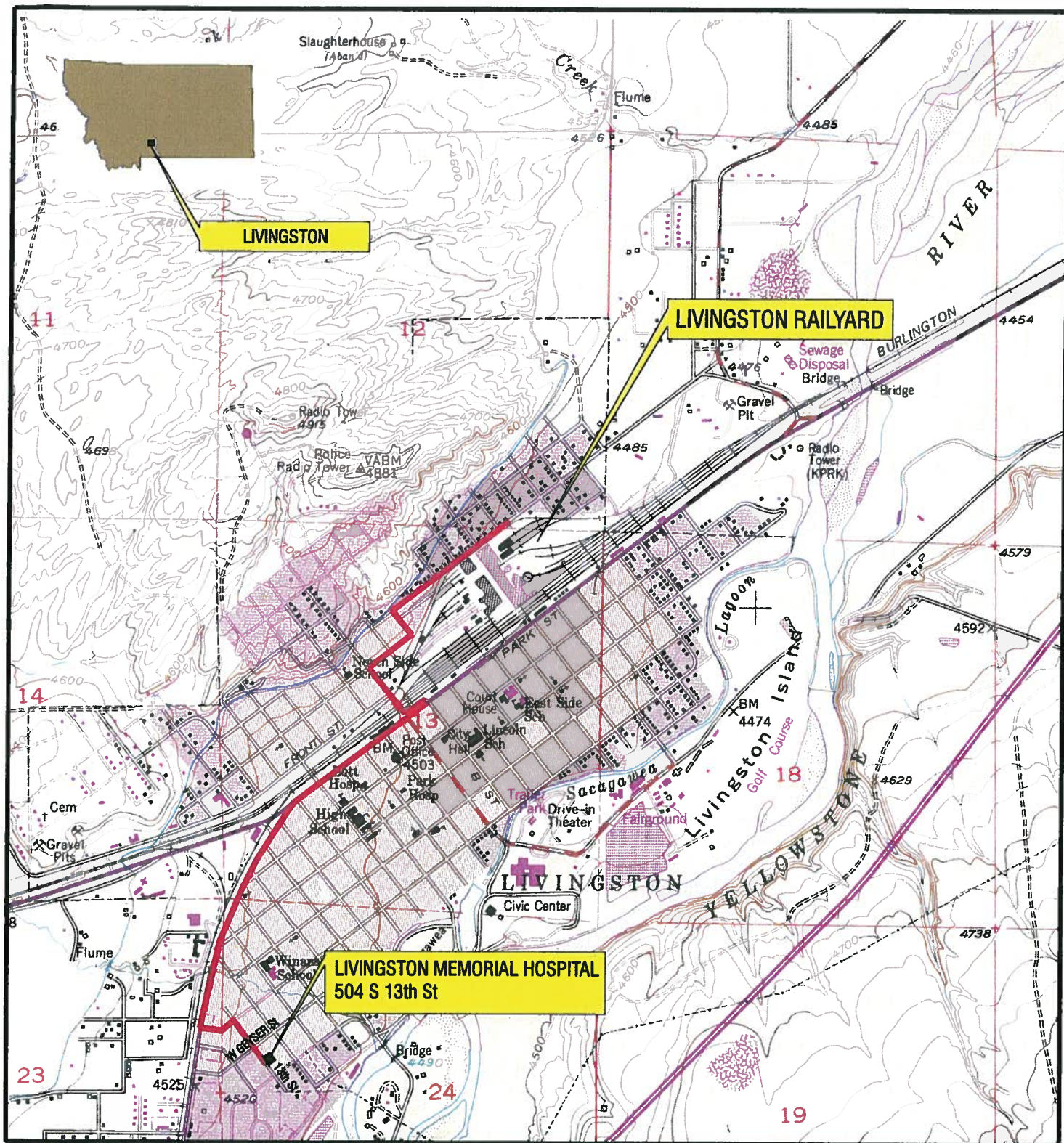
BASEMAP SOURCE:
HORIZONS, INC. RAPID, SD (1989)

Kennedy/Jenks Consultants
BURLINGTON NORTHERN LIVINGSTON SHOP
COMPLEX – LIVINGSTON, MT

**PROPOSED INJECTION AND
MONITORING WELL LOCATIONS**

Attachment 2

Route to Hospital



Directions to Hospital

- Proceed Southwest on E. Gallatin St.
- Turn LEFT onto N. Main St.
- Turn RIGHT onto Park St. (US-89)
- Turn LEFT onto S. 13th St.
- Hospital is on LEFT at 504 S. 13th St.

Kennedy/Jenks Consultants

BURLINGTON NORTHERN LIVINGSTON SHOP
COMPLEX-LIVINGSTON, MT

HOSPITAL LOCATION AND ROUTE MAP

3/05

059621.16/HASP/P05SK003

FIGURE 3

Attachment 3

Material Safety Data Sheets (MSDSs)

Section 1 - Product and Company Identification
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

Product Identification: ZINC ACETATE 2.0N FOR SULFIDE, VW3494
Date of MSDS: 06/02/1993 **Technical Review Date:** 09/13/1995
FSC: 6810 **NIIN:** LIIN: 00N063792
Submitter: N EN
Status Code: C
MFN: 01
Article: N
Kit Part: N

Manufacturer's Information

Manufacturer's Name: BDH INC
Manufacturer's Address1: 350 EVANS AVE
Manufacturer's Address2: TORONTO, ONTARIO, CANADA, NK 00000
Manufacturer's Country: NK
General Information Telephone: 416-255-8521
Emergency Telephone: 800-424-9300(CHEMTREC)
Emergency Telephone: 800-424-9300(CHEMTREC)
MSDS Preparer's Name: N/P
Proprietary: N
Reviewed: N
Published: Y
CAGE: 38445
Special Project Code: N

Contractor Information

Contractor's Name: BDH INC
Contractor's Address1: 350 EVANS AVE
Contractor's Address2: TORONTO, ONTARIO, CANADA, NK 00000
Contractor's Telephone: 416-255-8521/416-201-6383
Contractor's CAGE: 38445

Section 2 - Composition/Information on Ingredients
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

Ingredient Name: WATER
Ingredient CAS Number: 7732-18-5 **Ingredient CAS Code:** M
RTECS Number: ZC0110000 **RTECS Code:** M
=WT: =WT Code:
=Volume: =Volume Code:
>WT: >WT Code:
>Volume: >Volume Code:
<WT: <WT Code:
<Volume: <Volume Code:
% Low WT: % Low WT Code:

% High WT: % High WT Code:
% Low Volume: % Low Volume Code:
% High Volume: % High Volume Code:
% Text: N/K
% Enviromental Weight:
Other REC Limits: N/K
OSHA PEL: N/K (FP N) OSHA PEL Code: M
OSHA STEL: OSHA STEL Code:
ACGIH TLV: N/K (FP N) ACGIH TLV Code: M
ACGIH STEL: N/P ACGIH STEL Code:
EPA Reporting Quantity:
DOT Reporting Quantity:
Ozone Depleting Chemical: N

Ingredient Name: ZINC ACETATE DIHYDRATE; (ZINC ACETATE) SOL IN (H*2O):44%
LD50(ORAL,RAT):2460 MG/KG

Ingredient CAS Number: 5970-45-6 **Ingredient CAS Code:** M

RTECS Number: ZG8750000 **RTECS Code:** M

=WT: =WT Code:

=Volume: =Volume Code:

>WT: >WT Code:

>Volume: >Volume Code:

<WT: <WT Code:

<Volume: <Volume Code:

% Low WT: % Low WT Code:

% High WT: % High WT Code:

% Low Volume: % Low Volume Code:

% High Volume: % High Volume Code:

% Text: 22

% Enviromental Weight:

Other REC Limits: N/K

OSHA PEL: N/K (FP N) OSHA PEL Code: M

OSHA STEL: OSHA STEL Code:

ACGIH TLV: N/K (FP N) ACGIH TLV Code: M

ACGIH STEL: N/P ACGIH STEL Code:

EPA Reporting Quantity:

DOT Reporting Quantity:

Ozone Depleting Chemical: N

Section 3 - Hazards Identification, Including Emergency Overview

ZINC ACETATE 2.0N FOR SULFIDE, VW3494

Health Hazards Acute & Chronic: ACUTE:EYE CONTACT MAY RESULT IN SEVERE IRRITATION. MAY BE HARMFUL IF SWALLOWED. MAY PRODUCE ADVERSE MUTAGENIC EFFECTS (ZINC ACETATE). CHRONIC:NO INFORMATION AVAILABLE.

Signs & Symptoms of Overexposure:
SEE HEALTH HAZARDS.

Medical Conditions Aggravated by Exposure:
NONE IDENTIFIED.

LD50 LC50 Mixture: SEE INGREDIENT 1

Route of Entry Indicators:

Inhalation: YES

Skin: NO

Ingestion: YES

Carcinogenicity Indicators

NTP: NO

IARC: NO

OSHA: NO

Carcinogenicity Explanation: NOT RELEVANT

Section 4 - First Aid Measures
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

First Aid:

EYES: FLUSH WITH PLENTY OF WATER FOR AT LEAST 15 MINUTES WHILE HOLDING EYELIDS OPEN, HAVE EYE EXAMINED BY MED PERS. SKIN: WASH WITH SOAP AND WATER. GET MED ATTN IF IRRITATION DEVELOPS/PERSISTS. INGESTION: INDUCE VOMIT AS DIRECTED BY MED PERS. CALL MD IMMED. NEVER GIVE ANYTHING BY MOUTH TO AN UNCON PERSON. INHAL: REMOVE TO FRESH AIR. IF NOT BRTHG, TRAINED PERS SHOULD BEGIN ARTF RESP. SEEK MED ATTN.

Section 5 - Fire Fighting Measures
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

Fire Fighting Procedures:

WEAR NIOSH/MSHA APPROVED SCBA & FULL PROTECTIVE EQUIPMENT (FP N).

Unusual Fire or Explosion Hazard:

THERMAL DECOMPOSITION PRODUCES TOXIC FUMES. HAZARDOUS COMBUSTION PRODUCTS: CO*X.

Extinguishing Media:

USE AN EXTINGUISHER APPROPRIATE TO THE SURROUNDING MATERIAL THAT IS BURNING.

Flash Point: Flash Point Text: NOT APPLICABLE

Autoignition Temperature:

Autoignition Temperature Text: N/A

Lower Limit(s): N/A

Upper Limit(s): N/A

Section 6 - Accidental Release Measures
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

Spill Release Procedures:

EVACUATE AREA OF ALL UNNEC PERS. WEAR SUITABLE PROT EQUIP LISTED IN CTL MEASURES/PERS PROT. CNTN RELS & ELIM IT'S SOURCE, IF THIS CAN BE DONE W/OUT RISK. TAKE UP & CNTNRIZE FOR PROPER DISP AS DESCRIBE D UNDER DISP. COMPLY W/FED, STATE & LOC(SUP DAT)

Section 7 - Handling and Storage
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

Handling and Storage Precautions:

Other Precautions:

Section 8 - Exposure Controls & Personal Protection
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

Respiratory Protection:

USE NIOSH/MSHA APPROVED RESPIRATOR APPROPRIATE FOR EXPOSURE OF CONCERN (FP N). FUME HOOD AS APPROPRIATE.

Ventilation:

ENGINEERING AND/OR ADMINISTRATIVE CONTROLS SHOULD BE IMPLEMENTED TO REDUCE EXPOSURE.

Protective Gloves:

RUBBER, NEOPRENE OR EQUIVALENT.

Eye Protection: ANSI APPROVED CHEM WORKERS GOGGS(SUPDAT)

Other Protective Equipment: NO SPECIAL REQUIREMENTS. ANSI APPROVED EMERGENCY EYE BATH AND DELUGE SHOWER (FP N).

Work Hygenic Practices: NONE SPECIFIED BY MANUFACTURER.

Supplemental Health & Safety Information: SPILL PROC:REGULATIONS ON REPORTING RELEASES. EYE PROT:AND FULL LENGTH FACE SHIELD (FP N).

Section 9 - Physical & Chemical Properties
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

HCC:

NRC/State License Number:

Net Property Weight for Ammo:

Boiling Point: Boiling Point Text: N/K

Melting/Freezing Point: Melting/Freezing Text: N/K

Decomposition Point: Decomposition Text: N/K

Vapor Pressure: N/K **Vapor Density:** N/K

Percent Volatile Organic Content:

Specific Gravity: N/K

Volatile Organic Content Pounds per Gallon:

pH: 5-6

Volatile Organic Content Grams per Liter:

Viscosity: N/P

Evaporation Weight and Reference: N/K

Solubility in Water: SEE INGREDIENT 1

Appearance and Odor: CLEAR, COLORLESS LIQUID.

Percent Volatiles by Volume: N/K

Corrosion Rate: N/K

Section 10 - Stability & Reactivity Data
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

Stability Indicator: YES

Materials to Avoid:

ZINC SALTS, ACACIA, ALKALIES, OXALATES, CARBONATES, LIME WATER.

Stability Condition to Avoid:

NONE.

Hazardous Decomposition Products:

NONE IDENTIFIED.

Hazardous Polymerization Indicator: NO

Conditions to Avoid Polymerization:

NOT RELEVANT

Section 11 - Toxicological Information
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

Toxicological Information:

N/P

Section 12 - Ecological Information
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

Ecological Information:

N/P

Section 13 - Disposal Considerations
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

Waste Disposal Methods:

ALWAYS CONTACT A PERMITTED WASTE DISPOSER (TSD) TO ASSURE COMPLIANCE WITH ALL CURRENT LOCAL, STATE AND FEDERAL REGULATIONS.

Section 14 - MSDS Transport Information
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

Transport Information:
N/P

Section 15 - Regulatory Information
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

SARA Title III Information:
N/P
Federal Regulatory Information:
N/P
State Regulatory Information:
N/P

Section 16 - Other Information
ZINC ACETATE 2.0N FOR SULFIDE, VW3494

Other Information:
N/P

HAZCOM Label Information

Product Identification: ZINC ACETATE 2.0N FOR SULFIDE, VW3494
CAGE: 38445
Assigned Individual: N
Company Name: BDH INC
Company PO Box:
Company Street Address1: 350 EVANS AVE
Company Street Address2: TORONTO, ONTARIO, CANADA, NK 00000 NK
Health Emergency Telephone: 800-424-9300(CHEMTREC)
Label Required Indicator: Y
Date Label Reviewed: 09/13/1995
Status Code: C
Manufacturer's Label Number:
Date of Label: 09/13/1995
Year Procured: N/K
Organization Code: G
Chronic Hazard Indicator: N
Eye Protection Indicator: YES
Skin Protection Indicator: YES
Respiratory Protection Indicator: YES
Signal Word: DANGER
Health Hazard: Moderate
Contact Hazard: Severe
Fire Hazard: None
Reactivity Hazard: None

8/9/2002 9:16:07 AM

World Headquarters
Hach Company
P.O.Box 389
Loveland, CO USA 80539
(970) 669-3050

MSDS No: M00024

MATERIAL SAFETY DATA SHEET

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name: Ferrous Iron Reagent
Catalog Number: 2514025

Hach Company
P.O.Box 389
Loveland, CO USA 80539
(970) 669-3050

Emergency Telephone Numbers:
(Medical and Transportation)
(303) 623-5716 24 Hour Service
(515)232-2533 8am - 4pm CST

MSDS Number: M00024
Chemical Name: Not applicable
CAS No.: Not applicable
Chemical Formula: Not applicable
Chemical Family: Not applicable
Hazard: May cause irritation.
Date of MSDS Preparation:
Day: 23
Month: 09
Year: 2004

2. COMPOSITION / INFORMATION ON INGREDIENTS

1, 10-Phenanthroline

CAS No.: 5144898
TSCA CAS Number: 66-71-7
Percent Range: 1.0 - 10.0
Percent Range Units: weight / weight
LD50: Oral Rat LD₅₀ = 132 mg/kg
LC50: None reported
TLV: Not established
PEL: Not established
Hazard: May cause irritation.

Sodium Bicarbonate

CAS No.: 144-55-8
TSCA CAS Number: 144-558
Percent Range: 90.0 - 100.0
Percent Range Units: weight / weight
LD50: Oral rat LD₅₀ = 4220 mg/kg
LC50: None reported
TLV: Not established
PEL: Not established
Hazard: May cause irritation.

3. HAZARDS IDENTIFICATION

Emergency Overview:
Appearance: White powder
Odor: Not determined
MAY CAUSE EYE, SKIN AND RESPIRATORY TRACT IRRITATION

HMIS:

Health: 1

Flammability: 0

Reactivity: 0

Protective Equipment: X - See protective equipment, Section 8.

NFPA:

Health: 1

Flammability: 0

Reactivity: 0

Symbol: Not applicable

Potential Health Effects:

Eye Contact: May cause irritation

Skin Contact: May cause irritation

Skin Absorption: None reported

Target Organs: None reported

Ingestion: Very large doses may cause: abdominal pain gastrointestinal disturbances alkalosis which causes abnormally high alkali reserve of the blood and other body fluids hypotension

Target Organs: None reported

Inhalation: May cause: respiratory tract irritation

Target Organs: None reported

Medical Conditions Aggravated: Pre-existing: Kidney conditions

Chronic Effects: None reported

Cancer / Reproductive Toxicity Information:

This product does NOT contain any OSHA listed carcinogens.

This product does NOT contain any IARC listed chemicals.

This product does NOT contain any NTP listed chemicals.

Additional Cancer / Reproductive Toxicity Information: None reported

Toxicologically Synergistic Products: None reported

4. FIRST AID

Eye Contact: Immediately flush eyes with water for 15 minutes. Call physician.

Skin Contact (First Aid): Wash skin with soap and plenty of water. Call physician if irritation develops.

Ingestion (First Aid): Give large quantities of water. Call physician immediately.

Inhalation: Remove to fresh air.

5. FIRE FIGHTING MEASURES

Flammable Properties: Does not burn, but may melt in a fire, releasing toxic fumes.

Flash Point: Not applicable

Method: Not applicable

Flammability Limits:

Lower Explosion Limits: Not applicable

Upper Explosion Limits: Not applicable

Autoignition Temperature: Not applicable

Hazardous Combustion Products: Toxic fumes of: sodium monoxide nitrogen oxides. carbon monoxide, carbon dioxide.

Fire / Explosion Hazards: None reported

Static Discharge: None reported.

Mechanical Impact: None reported

Extinguishing Media: Water. Carbon dioxide Dry chemical.

Fire Fighting Instruction: As in any fire, wear self-contained breathing apparatus pressure-demand and full protective gear.

6. ACCIDENTAL RELEASE MEASURES

Spill Response Notice:

Only persons properly qualified to respond to an emergency involving hazardous substances may respond to a spill according to federal regulations (OSHA 29 CFR 1910.120(a)(v)) and per your company's emergency response plan and guidelines/procedures. See Section 13, Special Instructions for disposal assistance.

Containment Technique: Stop spilled material from being released to the environment.

Clean-up Technique: Scoop up spilled material into a large beaker and dissolve with water. Flush the spilled material to the drain with a large excess of water. Decontaminate the area of the spill with a weak acid solution.

Evacuation Procedure: Evacuate as needed to perform spill clean-up. If conditions warrant, increase the size of the evacuation.

Special Instructions (for accidental release): Not applicable

304 EHS RQ (40 CFR 355): Not applicable

D.O.T. Emergency Response Guide Number: None

7. HANDLING / STORAGE

Handling: Avoid contact with eyes skin. Do not breathe dust. Wash thoroughly after handling. Maintain general industrial hygiene practices when using this product.

Storage: Keep container tightly closed when not in use. Protect from: moisture oxidizers

Flammability Class: Not applicable

8. EXPOSURE CONTROLS / PROTECTIVE EQUIPMENT

Engineering Controls: Have an eyewash station nearby. Maintain general industrial hygiene practices when using this product.

Personal Protective Equipment:

Eye Protection: safety glasses with top and side shields

Skin Protection: disposable latex gloves

Inhalation Protection: adequate ventilation

Precautionary Measures: Avoid contact with: eyes skin. Do not breathe: dust. Wash thoroughly after handling. Keep away from: oxidizers

TLV: Not established

PEL: Not established

9. PHYSICAL / CHEMICAL PROPERTIES

Appearance: White powder

Physical State: Solid

Molecular Weight: Not applicable

Odor: Not determined

pH: Not determined

Vapor Pressure: Not applicable

Vapor Density (air = 1): Not applicable

Boiling Point: Not applicable

Melting Point: Not determined

Specific Gravity (water = 1): 2.10

Evaporation Rate (water = 1): Not applicable

Volatile Organic Compounds Content: Not applicable

Partition Coefficient (n-octanol / water): Not applicable

Solubility:

Water: Slightly soluble

Acid: Slightly soluble

Other: Not determined

Metal Corrosivity:

Steel: Not determined

Aluminum: Not determined

10. STABILITY / REACTIVITY

Chemical Stability: Stable when stored under proper conditions.

Conditions to Avoid: Excess moisture. Heating to decomposition.

Reactivity / Incompatibility: Incompatible with: oxidizers
Hazardous Decomposition: Toxic fumes of: nitrogen oxides sodium oxides carbon monoxide carbon dioxide
Hazardous Polymerization: Will not occur.

11. TOXICOLOGICAL INFORMATION

Product Toxicological Data:

LD50: None reported

LC50: None reported

Dermal Toxicity Data: None reported

Skin and Eye Irritation Data: Sodium Bicarbonate: Eye - rabbit - 100 mg/30 seconds - MILD; Skin - Human - 30 mg/3 days intermittent - MILD

Mutation Data: None reported

Reproductive Effects Data: None reported

Ingredient Toxicological Data: Sodium Bicarbonate: Oral rat LD₅₀ = 4220 mg/kg; 1, 10-Phenanthroline: Oral rat LD₅₀ = 132 mg/kg

12. ECOLOGICAL INFORMATION

Product Ecological Information: --

No ecological data available for this product.

Ingredient Ecological Information: --

No ecological data available for the ingredients of this product.

13. DISPOSAL CONSIDERATIONS

EPA Waste ID Number: None

Special Instructions (Disposal): Dilute material with excess water making a weaker than 5% solution. Open cold water tap completely, slowly pour the material to the drain.

Empty Containers: Rinse three times with an appropriate solvent. Dispose of empty container as normal trash.

NOTICE (Disposal): These disposal guidelines are based on federal regulations and may be superseded by more stringent state or local requirements. Please consult your local environmental regulators for more information.

14. TRANSPORT INFORMATION

D.O.T.:

D.O.T. Proper Shipping Name: Not Currently Regulated

--

DOT Hazard Class: NA

DOT Subsidiary Risk: NA

DOT ID Number: NA

DOT Packing Group: NA

I.C.A.O.:

I.C.A.O. Proper Shipping Name: Not Currently Regulated

--

ICAO Hazard Class: NA

ICAO Subsidiary Risk: NA

ICAO ID Number: NA

ICAO Packing Group: NA

I.M.O.:

I.M.O. Proper Shipping Name: Not Currently Regulated

--

I.M.O. Hazard Class: NA

I.M.O. Subsidiary Risk: NA

I.M.O. ID Number: NA

I.M.O. Packing Group: NA

Additional Information: This product may be shipped as part of a chemical kit composed of various compatible dangerous goods for analytical or testing purposes. This kit would have the following classification: Proper Shipping Name: Chemical Kit Hazard Class: 9 UN Number 3316

15. REGULATORY INFORMATION

U.S. Federal Regulations:

O.S.H.A.: This product meets the criteria for a hazardous substance as defined in the Hazard Communication Standard. (29 CFR 1910.1200)

E.P.A.:

S.A.R.A. Title III Section 311/312 Categorization (40 CFR 370): Immediate (Acute) Health Hazard

S.A.R.A. Title III Section 313 (40 CFR 372): This product does NOT contain any chemical subject to the reporting requirements of Section 313 of Title III of SARA.

--

302 (EHS) TPQ (40 CFR 355): Not applicable

304 CERCLA RQ (40 CFR 302.4): Not applicable

304 EHS RQ (40 CFR 355): Not applicable

Clean Water Act (40 CFR 116.4): Not applicable

RCRA: Contains no RCRA regulated substances.

C.P.S.C.: Not applicable

State Regulations:

California Prop. 65: No Prop. 65 listed chemicals are present in this product.

Identification of Prop. 65 Ingredient(s): None

Trade Secret Registry: Not applicable

National Inventories:

U.S. Inventory Status: All ingredients in this product are listed on the TSCA 8(b) Inventory (40 CFR 710).

TSCA CAS Number: Not applicable

16. OTHER INFORMATION

Intended Use: Iron determination

References: TLV's Threshold Limit Values and Biological Exposure Indices for 1992-1993. American Conference of Governmental Industrial Hygienists, 1992. Air Contaminants, Federal Register, Vol. 54, No. 12. Thursday, January 19, 1989. pp. 2332-2983. 29 CFR 1900 - 1910 (Code of Federal Regulations - Labor). In-house information. Technical Judgment. Fire Protection Guide on Hazardous Materials, 10th Ed. Quincy, MA: National Fire Protection Fire Protection Guide on Hazardous Materials, 10th Ed. Quincy, MA: National Fire Protection Association, 1991.

Revision Summary: Updates in Section(s) 14,

Legend:

NA - Not Applicable	w/w - weight/weight
ND - Not Determined	w/v - weight/volume
NV - Not Available	v/v - volume/volume

USER RESPONSIBILITY: Each user should read and understand this information and incorporate it in individual site safety programs in accordance with applicable hazard communication standards and regulations.

THE INFORMATION CONTAINED HEREIN IS BASED ON DATA CONSIDERED TO BE ACCURATE. HOWEVER, NO WARRANTY IS EXPRESSED OR IMPLIED REGARDING THE ACCURACY OF THESE DATA OR THE RESULTS TO BE OBTAINED FROM THE USE THEREOF.

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Material Data Safety Sheet (MSDS): HYDROCHLORIC ACID

1. Product Identification	7. Handling and Storage
2. Composition	8. Exposure Controls/Personal Protection
3. Hazards Identification	9. Physical and Chemical Properties
4. First Aid Measures	10. Stability and Reactivity
5. Fire Fighting Measures	11. Toxicological Information
6. Accidental Release Measures	12. Ecological Information
	13. Disposal Considerations
	16. Other Information

Note: This information sheet has been re-formatted for better clarity by the Department of Earth Sciences.

Some of the data such as information on shipping and weapons treaties were intentionally left out. If you want to look at the complete MSDS, you can either check one of the hardcopy versions in the Department,

contact the manufacturer, or check one of the various Web-based databases such as those compiled by BU's Office of Environmental Health & Safety (www.bu.edu/ehs/msds/index.htm).

[Return to MSDS Index](#)

1. Product Identification

MSDS Name: **Hydrochloric Acid**, Reagent ACS

Chlorohydric acid, hydrogen chloride, muriatic acid, spirits of salt.

Company Identification: Acros Organics N.V.

One Reagent Lane

Fairlawn, NJ 07410

For information in North America, call: 800-ACROS-01

For emergencies in the US, call CHEMTREC: 800-424-9300

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2. Composition/Information on Ingredients

CAS#	Chemical Name	%	EINECS#
------	---------------	---	---------

7647-01-0	Hydrochloric acid, reagent ACS	37%	231-595-7
7732-18-5	Water	Balance	231-791-2

Hazard Symbols: C

Risk Phrases: 34 37

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3. Hazards Identification

Emergency Overview

EMERGENCY OVERVIEW

Appearance: Clear, colorless to faintly yellow.

Danger! Corrosive. Sensitizer. Causes eye and skin burns. May cause severe respiratory and digestive tract irritation with possible burns.

Target Organs: None.

Potential Health Effects

Eye:

May cause irreversible eye injury. Vapor or mist may cause irritation and severe burns. Contact with liquid is corrosive to the eyes and causes severe burns. May cause painful sensitization to light. May cause conjunctivitis.

Skin:

May be absorbed through the skin in harmful amounts. Contact with liquid is corrosive and causes severe burns and ulceration. May cause photosensitization in certain individuals.

Ingestion:

May cause circulatory system failure. Causes severe digestive tract burns with abdominal pain, vomiting, and possible death. May cause corrosion and permanent tissue destruction of the esophagus and digestive tract.

Inhalation:

Causes severe irritation of upper respiratory tract with coughing, burns, breathing difficulty, and possible coma. May cause pulmonary edema and severe respiratory disturbances.

Chronic:

Prolonged or repeated skin contact may cause dermatitis. Repeated exposure may cause erosion of teeth. May cause conjunctivitis and photosensitization.

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4. First Aid Measures

Eyes:

Flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower lids. Get medical aid

immediately. Do NOT allow victim to rub or keep eyes closed.

Skin:

Get medical aid. Rinse area with large amounts of water for at least 15 minutes. Remove contaminated clothing and shoes.

Ingestion:

Do NOT induce vomiting. If victim is conscious and alert, give 2-4 cupfuls of milk or water. Get medical aid immediately.

Inhalation:

Remove from exposure to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid.

Notes to Physician:

Treat symptomatically and supportively.

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5. Fire Fighting Measures

General Information:

As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. Not flammable, but reacts with most metals to form flammable hydrogen gas. Use water spray to keep fire-exposed containers cool.

Extinguishing Media:

Substance is nonflammable; use agent most appropriate to extinguish surrounding fire.

Autoignition Temperature: Not available.

Flash Point: Not available.

NFPA Rating: Not published.

Explosion Limits, Lower: Not available.

Upper: Not available.

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6. Accidental Release Measures

General Information: Use proper personal protective equipment as indicated in Section 8.

Spills/Leaks:

Large spills may be neutralized with dilute alkaline solutions of soda ash, or lime. Absorb spill using an absorbent, non-combustible material such as earth, sand, or vermiculite.

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7. Handling and Storage

Handling:

Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Use with adequate ventilation. Do not get on skin or in eyes. Do not ingest or inhale.

Storage:

Keep away from heat and flame. Do not store in direct sunlight. Store in a cool, dry, well-ventilated area away from incompatible substances.

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8. Exposure Controls/Personal Protection

Engineering Controls:

Use adequate general or local exhaust ventilation to keep airborne concentrations below the permissible exposure limits.

Exposure Limits

Chemical Name ACGIH NIOSH OSHA - Final PELs

Hydrochloric acid, reagent ACS C 5 ppm; C 7.5 mg/m³ 50 ppm IDLH C 5 ppm; C 7 mg/m³

OSHA Vacated PELs:

Hydrochloric acid, reagent ACS:

No OSHA Vacated PELs are listed for this chemical.

Personal Protective Equipment

Eyes:

Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.

Skin:

Wear appropriate protective gloves to prevent skin exposure.

Clothing:

Wear appropriate protective clothing to prevent skin exposure.

Respirators:

Follow the OSHA respirator regulations found in 29CFR 1910.134 or European Standard EN 149. Always use a NIOSH or European Standard EN 149 approved respirator when necessary.

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9. Physical and Chemical Properties (Hydrochloric Acid)

Appearance:	Clear, colorless to faintly yellow liquid
Odor:	Strong, pungent
Solubility:	823g/L water at 32F
Density:	1.16-1.19
pH:	1.1 (0.1N sol)
% Volatiles by volume @ 21C (70F):	Not available
Boiling Point:	230 deg F
Melting Point:	-101 deg F
Vapor Density (Air=1):	1.257
Vapor Pressure:	160 mm Hg
Evaporation Rate (Butyl acetate =1):	2.0

Molecular Formula: HCl

Molecular Weight: 36.46

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10. Stability and Reactivity

Chemical Stability:

Stable under normal temperatures and pressures.

Conditions to Avoid:

Incompatible materials, light.

Incompatibilities with Other Materials:

Acetate, acetic anhydride, alcohols + hydrogen cyanide, 2-aminoethanol, ammonium hydroxide, calcium carbide, calcium phosphide, cesium acetylene carbide, cesium carbide, chlorosulfonic acid, 1,1-difluoroethylene, ethylene diamine, ethyleneimine, fluorine, lithium silicide, magnesium boride, mercuric sulfate, oleum, perchloric acid, potassium permanganate, b-propiolactone, propylene oxide, rubidium acetylene carbide, rubidium carbide, silver perchlorate + carbon tetrachloride, sodium, sodium hydroxide, sulfuric acid, uranium phosphide, vinyl acetate. Substance polymerizes on contact with

aldehydes or epoxides.

Hazardous Decomposition Products:

Hydrogen chloride, chlorine, carbon monoxide, carbon dioxide, hydrogen gas.

Hazardous Polymerization: May occur.

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11. Toxicological Information

RTECS#:

CAS# 7647-01-0: MW4025000

CAS# 7732-18-5: ZC0110000

LD50/LC50:

CAS# 7647-01-0: Inhalation, mouse: LC50 =1108 ppm/1H; Inhalation, rat: LC50 =3124 ppm/1H; Oral, rabbit: LD50 = 900 mg/kg.

CAS# 7732-18-5: Oral, rat: LD50 = >90 mL/kg.

Carcinogenicity:

Hydrochloric acid, reagent ACS -

IARC: Group 3 carcinogen

Epidemiology:

No information available.

Teratogenicity:

Embryo or Fetus: Stunted fetus, ihl-rat TCLo=450 mg/m3/1H Specific

Developmental Abnormalities: homeostasis, ihl-rat TCLo=450 mg/m3/1H.

Reproductive Effects:

No information available.

Neurotoxicity:

No information available.

Mutagenicity:

No information available.

Other Studies:

None.

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12. Ecological Information

Ecotoxicity:

Trout LC100=10 mg/L/24H Shrimp LC50=100-330 ppm Starfish LC50=100-330mg/L/48H Shore crab LC50=240 mg/L/48H Chronic plant toxicity=100 ppm

Environmental Fate:

Substance will neutralize soil carbonate-based components.

Physical/Chemical:

No information available.

Other:

None.

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13. Disposal Considerations

Dispose of in a manner consistent with federal, state, and local regulations.

RCRA D-Series Maximum Concentration of Contaminants: None listed.

RCRA D-Series Chronic Toxicity Reference Levels: None listed.

RCRA F-Series: None listed.

RCRA P-Series: None listed.

RCRA U-Series: None listed

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16. Other Information

MSDS Creation Date: 11/09/1995 Revision #4 Date: 4/28/1998

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no way shall Fisher be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if Fisher has been advised of the possibility of such damages.

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Section 1 Chemical Product and Company Identification

PRODUCT NAME: RemOx® L ISCO Reagent	Revision Date: January 2006
TRADE NAME: RemOx® L ISCO Reagent	

USES OF SUBSTANCE: RemOx® L ISCO Reagent is a liquid oxidant recommended for in-situ and ex-situ remediation of sites that require a strong oxidant.

COMPANY NAME (Europe): CARUS NALON S.L. COMPANY NAME (US): CARUS CHEMICAL COMPANY	COMPANY ADDRESS: Carus Nalon S.L. Barrio Nalon, s/n 33100 Trubia-Oviedo Espana, Spain
	INFORMATION: (34) 985-785-513 (34) 985-785-513 www.caruseurope.com (Web) carus@carusnalon.com (Email)
	EMERGENCY TELEPHONE: (34) 985-785-513
	COMPANY ADDRESS: 315 Fifth Street Peru, IL 61354, USA INFORMATION: (815)-223-1500 www.caruschem.com (Web) salesmkt@caruschem.com (Email) EMERGENCY TELEPHONE: (800) 435 -6856 (USA) (800) 424-9300 (CHEMTREC, USA) (815-223-1500 (Other countries)

Section 2 Hazardous Ingredients

Material or Component	CAS No.	%	Hazard Data
Sodium Permanganate	10101-50-5	40	PEL/C 5 mg Mn per cubic meter of air TLV-TWA 0.2 mg Mn per cubic meter of air
HAZARD SYMBOLS: <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> O </div> <div style="text-align: center;"> Xn </div> <div style="text-align: center;"> N </div> </div>			
RISK PHRASES: 8 Contact with combustibles may cause fire. 22 Harmful if swallowed. 50/53 Very toxic to aquatic organisms, may cause long-term effects in the aquatic environment.			
SAFETY PHRASES: 17 Keep away from combustible materials. 24/25 Avoid contact with skin and eyes. 26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice			



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Section 3 Hazards Identification

1. Eye Contact
RemOx® L ISCO Reagent is damaging to eye tissue on contact. It may cause burns that result in damage to the eye.
2. Skin Contact
Momentary contact of solution at room temperature may be irritating to the skin, leaving brown stains. Prolonged contact is damaging to the skin.
3. Inhalation
Acute inhalation toxicity data are not available. However, airborne concentrations of RemOx® L ISCO Reagent in the form of mist may cause irritation to the respiratory tract.
4. Ingestion
RemOx® L ISCO Reagent if swallowed, may cause burns to mucous membranes of the mouth, throat, esophagus, and stomach.

Section 4 First Aid Measures

1. Eyes
Immediately flush eyes with large amounts of water for at least 15 minutes holding lids apart to ensure flushing of the entire surface. Do not attempt to neutralize chemically. Seek medical attention immediately. Note to physician: Decomposition products are alkaline.
2. Skin
Immediately wash contaminated areas with water. Remove contaminated clothing and footwear. (Caution: Solution may ignite certain textiles). Wash clothing and decontaminate footwear before reuse. Seek medical attention immediately if irritation is severe and persistent.
3. Inhalation
Remove person from contaminated area to fresh air. If breathing has stopped, resuscitate and administer oxygen if readily available. Seek medical attention immediately.
4. Ingestion
Never give anything by mouth to an unconscious or convulsing person. If person is conscious, give large quantities of water or milk. Seek medical attention immediately.

Section 5 Fire Fighting Measures

NFPA* HAZARD SIGNS:

Health Hazard	1	=	Materials which under fire conditions would give off irritating combustion products. (less than 1 hour exposure)	Materials which on the skin could cause irritation.
Flammability Hazard	0	=	Materials that will not burn.	
Reactivity Hazard	0	=	Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.	
Special Hazard	OX	=	Oxidizer	

*National Fire Protection Association 704

FIRST RESPONDERS:

Wear protective gloves, boots, goggles, and respirator. In case of fire, wear positive pressure breathing apparatus. Approach incident with caution. Use 2004 Emergency Response Guidebook (U.S. DOT RSPA, TC and STC). Guide No. 140. (<http://hazmat.dot.gov/pubs/crg2004/crg2004.pdf>).



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FLASHPOINT	None
FLAMMABLE OR EXPLOSIVE LIMITS	Lower: Nonflammable Upper: Nonflammable
EXTINGUISHING MEDIA	Use large quantities of water. Water will turn pink to purple if in contact with RemOx® L ISCO Reagent. Dike to contain. Do not use dry chemicals, CO ₂ Halon® or foams.
SPECIAL FIREFIGHTING PROCEDURES	If material is involved in fire, flood with water. Cool all affected containers with large quantities of water. Apply water from as far as a distance as possible. Wear self-contained breathing apparatus and full protective clothing.
UNUSUAL FIRE AND EXPLOSION	Powerful oxidizing material. May decompose spontaneously if exposed to heat (135°C/275°F). May be explosive in contact with certain other chemicals (Section 10). May react violently with finely divided and readily oxidizable substances. Increases burning rate of combustible material. May ignite wood and cloth.

Section 6 Accidental Release Measures

PERSONAL PRECAUTIONS

Personnel should wear protective clothing suitable for the task. Remove all ignition sources and incompatible materials before attempting clean up.

ENVIRONMENTAL PRECAUTIONS:

Do not flush into sanitary sewer system or surface water. If accidental release into the environment occurs, inform the responsible authorities. Keep the product away from drains, sewers, surface and ground water and soil.

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

Contain spill by collecting the liquid in a pit or holding behind a dam (sand or soil). Dilute to approximately 6% with water, and then reduce with sodium thiosulfate, a bisulfite or ferrous salt solution. The bisulfite or ferrous salt may require some dilute sulfuric acid (10% w/w) to promote reduction. Neutralize with sodium carbonate to neutral pH, if acid was used. Decant or filter and deposit sludge in approved landfill. Where permitted, the sludge may be drained into sewer with large quantities of water. To clean contaminated floors, flush with abundant quantities of water into sewer, if permitted by federal, state, and local regulations. If not, collect water and treat as above.



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Section 7 Handling and Storage

WORK/HYGIENIC PRACTICES

Wash hands thoroughly with soap and water after handling RemOx® L ISCO Reagent. Do not eat, drink or smoke when working with RemOx® L ISCO Reagent. Wear proper protective equipment. Remove clothing, if it becomes contaminated.

VENTILATION REQUIREMENTS

Provide sufficient mechanical and/or local exhaust to maintain exposure below the TLV/TWA.

CONDITIONS FOR SAFE STORAGE

Store in accordance with NFPA 430 requirements for Class II oxidizers. Protect containers from physical damage. Store in a cool, dry area in closed containers. Segregate from acids, peroxides, formaldehyde, and all combustible, organic, or easily oxidizable materials including antifreeze and hydraulic fluid.

Section 8 Exposure Controls and Personal Protection

RESPIRATORY PROTECTION

In cases where overexposure to mist may occur, the use of an approved NIOSH-MSHA mist respirator or an air supplied respirator is advised. Engineering or administrative controls should be implemented to control mist.

EYE

Faceshield, goggles, or safety glasses with side shields should be worn. Provide eyewash in working area.

GLOVES

Rubber or plastic gloves should be worn.

OTHER PROTECTIVE EQUIPMENT

Normal work clothing covering arms and legs, and rubber, or plastic apron should be worn. Caution: If clothing becomes contaminated, wash off immediately. Spontaneous ignition may occur with cloth or paper.

Section 9 Physical and Chemical Properties

APPEARANCE AND ODOR

Dark purple solution, odorless

BOILING POINT, 760 mm Hg

105 °C

VAPOR PRESSURE (mm Hg)

760 mm at 105°C

SOLUBILITY IN WATER % BY SOLUTION

Miscible in all proportions

PERCENT VOLATILE BY VOLUME

61% (as water)

EVAPORATION RATE

Same as water

FREEZING POINT

-15.0 °C

SPECIFIC GRAVITY

1.36-1.39

pH

5-9

OXIDIZING PROPERTIES

Strong oxidizer. May ignite wood and cloth.

EXPLOSIVE PROPERTIES

Explosive in contact with sulfuric acid or peroxides, or



RemOx®L

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readily oxidizable substances.

Section 10 Stability and Reactivity

STABILITY	Under normal conditions, the material is stable.
CONDITIONS TO AVOID could	Contact with incompatible materials or heat (135°C / 275°F) result in violent exothermic chemical reaction.
INCOMPATIBLE MATERIALS	Acids, peroxides, formaldehyde, antifreeze, hydraulic fluids, and all combustible organic or readily oxidizable materials, including metal powders. With hydrochloric acid, toxic chlorine gas is liberated.
HAZARDOUS DECOMPOSITION PRODUCTS	When involved in a fire, liquid permanganate may form corrosive fumes.
CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION	Material is not known to polymerize.

Section 11 Toxicological Information

SODIUM PERMANGANATE: Acute oral LD₅₀ not known.

1. Acute toxicity

Irritating to body tissue with which it comes into contact. No acute toxicity data is available for sodium permanganate. Toxicity is expected to be similar to that of potassium permanganate. The toxicity data for potassium permanganate is given below:

Ingestion:

LD 50 oral rat: 780 mg/kg male (14 days); 525 mg/kg female (14 days).

Harmful if swallowed. ALD: 10g. Ingestion may cause nausea, vomiting, sore throat, stomach-ache and eventually lead to a perforation of the intestine. Liver and kidney injuries may occur.

Skin contact:

LD 50 dermal no data available.

The product may be absorbed into the body through the skin. Major effects of exposure: severe irritation, brown staining of skin.

Inhalation:

LC 50 inhal. no data available.

The product may be absorbed into the body by inhalation. Major effects of exposure: respiratory disorder, cough.

2. Chronic toxicity

No known cases of chronic poisoning due to permanganates have been reported. Prolonged exposure, usually over many years, to heavy concentrations of manganese oxides in the form of dust and fumes may lead to



RemOx® L ISCO Reagent

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chronic manganese poisoning, chiefly involving the central nervous system.

3. Carcinogenicity

Sodium permanganate has not been classified as a carcinogen by ACGIH, NIOSH, OSHA, NTP, or IARC.

4. Medical Conditions Generally Aggravated by Exposure

Sodium permanganate solution will cause further irritation of tissue, open wounds, burns or mucous membranes.

Section 12 Ecological Information

Entry to the Environment

Permanganate has a low estimated lifetime in the environment, being readily converted by oxidizable materials to insoluble MnO_2 .

Bioconcentration Potential

In non-reducing and non-acidic environments MnO_2 is insoluble and has a very low bioaccumulative potential.

Aquatic Toxicity

No data.

Section 13 Disposal Considerations

Waste Disposal

RemOx® L ISCO Reagent, once it becomes a waste, is considered a D001 hazardous (ignitable) waste. For disposal of RemOx® L ISCO Reagent solutions, follow procedures in Section 6 and deactivate the permanganate to insoluble manganese dioxide. Dispose of it in a permitted landfill. Contact Carus Chemical Company for additional recommendations.

Section 14 Transport Information

USA (land, D.O.T.)	Proper Shipping Name: 49 CFR172.101 Permanganates, inorganic, aqueous	
	solution, n.o.s (contains sodium permanganate)	
	Hazard Class:	49 CFR172.101....Oxidizer
	ID Number:	49 CFR172.101....UN 3214
	Packing Group:	49 CFR172.101....II
European Labeling in accordance Road/Rail Transport (ADR/RID)	Division:	49 CFR172.101....5.1
	ID Number:	UN 3214
	ADR/RID Class	5.1
	Description of Goods:	Permanganates, inorganic, aqueous solution, n.o.s (contains sodium permanganate)
European Labeling in accordance with EC directive (Water, I.M.O.)	Hazard Identification No.	50
	Proper Shipping Name: Permanganates, inorganic, aqueous solution, n.o.s (contains sodium permanganate)	
	Hazard Class:	Oxidizer
	ID Number:	UN 3214



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	Packing Group: II Division: 5.1 Marine Pollutant: No
European Labeling in accordance with EC directive (Air, I.C.A.O.)	Proper Shipping Name: Permanganates, inorganic, aqueous solution, n.o.s (contains sodium permanganate) Hazard Class: Oxidizer ID Number: UN 3214 Packing Group: II Division: 5.1

Section 15 Regulatory Information (Sodium Permanganate)

TSCA	Listed in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory.
CERCLA	Not listed.
RCRA	Oxidizers such as RemOx® L ISCO Reagent solution meet the criteria of ignitable waste. 40 CFR 261.21.
SARA TITLE III Information	
Section 302/303	Extremely hazardous substance: Not listed
Section 311/312	Hazard categories: Fire, acute and chronic toxicity.
Section 313	RemOx® L ISCO Reagent contains 40% manganese compounds as part of the chemical and is subject to the reporting requirements of Section 313 of Title III, Superfund Amendments and Reauthorization Act of 1986 and 40 CFR 372.
FOREIGN LIST	Canadian Non-Domestic Substance List , EINECS

Section 16 Other Information

NIOSH	National Institute for Occupational Safety and Health
MSHA	Mine Safety and Health Administration
OSHA	Occupational Safety and Health Administration
NTP	National Toxicology Program
IARC	International Agency for Research on Cancer
PEL	Permissible Exposure Limit
C	Ceiling Exposure Limit
TLV-TWA	Threshold Limit Value-Time Weighted Average
CAS	Chemical Abstract Service
EINECS	Inventory of Existing Chemical Substances (European)

Chithambarathanu Pillai (S.O.F.)
January 2006

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RemOx® L ISCO Reagent

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handling, and use of the product are beyond the control of Carus Chemical Company, and shall be the sole responsibility of the holder or user of the product.



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Responsible Care®
Good Chemistry at Work

Appendix H

Environmental Requirements, Criteria, and Limitations for Task F Stage I – Part 2 Pilot Test Work Plan

APPENDIX H

ENVIRONMENTAL REQUIREMENTS, CRITERIA, AND LIMITATIONS

Remedial actions undertaken pursuant to the Comprehensive Environmental Cleanup and Responsibility Act (CECRA), Section 75-10-701, et seq., Montana Code Annotated (MCA 1991), must "attain a degree of cleanup of the hazardous or deleterious substance and control of a threatened release or further release of that substance that assures present and future protection of public health, safety, and welfare and of the environment" [Section 75-10-721(1) (MCA 1991)]. Additionally, the Montana Department of Environmental Quality (DEQ) "shall require cleanup consistent with applicable state or federal environmental requirements, criteria, or limitations" (ERCLs) and "shall consider and may require cleanup consistent with substantive state or federal ERCLS that are well-suited to the site conditions" [Section 75-10-721(2)(a) and (b) (MCA 1991)].

"Applicable" requirements are those that by their terms meet the jurisdictional prerequisites and apply to a given action, item, or characteristic at the site. "Well-suited" requirements are those requirements that are not applicable, but address situations or problems sufficiently similar to those at the site that they are well-suited for use at the site.

ERCLs are generally of three types: contaminant-specific, location-specific, and action-specific. Contaminant-specific requirements are those that establish an allowable level or concentration of a hazardous or deleterious substance in the environment or that prescribe a level or method of treatment for a hazardous or deleterious substance. Action-specific requirements are those that are triggered by the performance of a certain activity as part of a particular remedy. Location-specific requirements are those that serve as restrictions on the concentration of a hazardous or deleterious substance or the conduct of activities solely they are in specific locations or affect specified types of areas.

ERCLs for the remedial action at the Burlington Northern Livingston Shop Complex were prepared by DEQ and were included in Appendix A of the *Record of Decision* (DEQ 2001). The following table presents a summary of the ERCLs from the ROD, including a description of each ERCL along with the regulatory citation(s), and an analysis of how the activities that will be performed during implementation of the Task F Stage I – Part 2 pilot test work plan (pilot test work plan) will comply with these ERCLs. ERCLs pertinent to the pilot test are shaded in yellow.

Activities to be performed during implementation of the pilot test work plan comply with ERCLs.

ANALYSIS OF ENVIRONMENTAL REQUIREMENTS, CRITERIA, AND LIMITATIONS (ERCLS)^(a) FOR TASK F STAGE I - PART 2 PILOT TEST WORK PLAN
Burlington Northern Livingston Shop Complex

Federal or State ERCL Citation	Description	Compliance
FEDERAL AND STATE CONTAMINANT SPECIFIC ERCLS		
Surface and Groundwater Quality Standards (Applicable)		
Section 75-5-605, Montana Code Annotated (MCA)	<u>Causing of Pollution</u> Section 75-5-605 of the Montana Water Quality Act prohibits the causing of pollution of any state waters. Section 75-5-103(21)(a)(i) defines pollution as contamination or other alteration of physical, chemical, or biological properties of state waters which exceeds that permitted by the water quality standards. <u>Placement of Wastes</u> Section 75-5-605, MCA states that it is unlawful to place or cause to be placed any wastes where they will cause pollution of any state waters. Any permitted placement of waste is not placement if the agency's permitting authority contains provisions for review of the placement of materials to ensure it will not cause pollution to state waters.	Activities proposed in the Task F Stage I - Part 2 pilot test work plan (pilot test work plan) will not impact surface water. The sodium permanganate pilot test involves the injection of this chemical into the subsurface through soil borings. This chemical will introduce permanganate ions and potentially thallium and iron. It is expected that their presence in the groundwater will be short lived as the constituents precipitate from the groundwater. Hexavalant chromium concentrations may increase after the injection but attenuation of dissolved chromium occurs shortly after the permanganate has been consumed. Groundwater monitoring for metals of concern will be conducted during the pilot test. Please refer to Attachment 1 of <i>Response to Comments - Final Task F Stage I - Part 2 Pilot Test Work Plan for VOC-Containing Alluvial Aquifer Groundwater</i> dated 11 July 2008.
Section 75-5-303, MCA	<u>Nondegradation</u> Section 75-5-303, MCA states that existing uses of state waters and the level of water quality necessary to protect the uses must be maintained and protected, with certain limited exceptions.	
Groundwater Quality Standards		
40 Code of Federal Regulations (CFR) 141	<u>Maximum Contaminant Levels and Maximum Contaminant Level Goals (Well-Suited)</u> Because the aquifer affected by the site is currently and has been used as a drinking water source, the MCLs and non-zero MCLGs specified in 40 CFR Part 141 (Primary Drinking Water Standards) are well-suited requirements which are ultimately to be attained by the remedy for the site ¹ . Because many of the MCLs are equivalent with the State groundwater standards, the Primary Drinking Water Standards are listed below with the State groundwater standards.	The Record of Decision (ROD) specifies groundwater remediation as part of the remedial action and allows the treatment of groundwater as part of the selected remedy. This pilot test work plan includes pilot testing a treatment technology to assess whether it will achieve the ROD cleanup levels.
40 CFR 143.3	<u>Secondary Maximum Contaminant Levels (Well-Suited)</u> Because the aquifer affected by the site is currently and has been used as a drinking water source, the Secondary Maximum Contaminant Levels (SMCLs) specified in 40 CFR Part 143.3 are well-suited requirements which are ultimately to be attained by the remedy for the site. 40 CFR 143.3 contains standards for color, odor (3 threshold odor number) and corrosivity which are well-suited to the remedial action.	
Administrative Rules of Montana (ARM) 17.30.1006	<u>Montana Groundwater Pollution Control System (Applicable)</u> ARM 17.30.1006 classifies groundwater into Classes I through IV based upon its specific conductance and establishes the groundwater quality standards applicable with respect to each groundwater classification. Based upon its specific conductance, the groundwater at the site must meet the standards for Class I groundwater. These standards are applicable. Concentrations of substances in Class I may not exceed the human health standards for groundwater listed in department Circular WQB-7. ² For the primary contaminants of concern, the Circular WQB-7 standards and MCLs are listed below. For all contaminants of concern except vinyl chloride, the MCLs and Circular WQB-7 standards are equivalent. ³ All levels are ug/l and are dissolved phase. VOCs: Tetrachloroethene - 5.0; Trichloroethene - 5.0; Cis-1,2-Dichloroethene - 70; Vinyl chloride - 0.15; Chlorobenzene - 100; 1,4-Dichlorobenzene - 75 PAHs (SVOCs): Acenaphthene - 420; Anthracene - 2,100; Benzo(a)anthracene - 0.48; Benzo(a)pyrene - 0.048; Benzo(b)fluoranthene - 0.48; Benzo(k)fluoranthene - 4.79; Chrysene - 48; Dibenzo(a,h)anthracene - 0.048; Fluoranthene - 280; Fluorene - 280; Indeno(1,2,3-cd)pyrene - 0.48; Naphthalene - 28; Pyrene - 210 Lead - 15 For concentrations of parameters for which human health standards are not listed in WQB-7, ARM 17.30.1006 allows no increase of a parameter to a level that renders the waters harmful, detrimental or injurious to the beneficial uses listed for Class I water. This includes the following petroleum constituents. All levels are "ug/l" and are dissolved phase.	DEQ determined that the pilot testing of sodium permanganate injection does not require a Montana Groundwater Pollution Control System (MGWPCS) permit under ARM 17.30.1023, because the pilot test is being performed under the Spring 2005 SOW. All substantive requirements of these regulations will be met. 40 CFR Part 143.3 and the Numeric Water Quality Standards for Montana's surface and groundwaters (formerly WQB-7 and now DEQ-7) contain a secondary MCL for manganese in groundwater of 0.05 milligrams per Liter (mg/L). Under DEQ-7, the concentration of manganese must not reach values that interfere with the uses specified in the surface and groundwater standards. Because the manganese and chromium will attenuate shortly after application (please refer to Attachment 1 of <i>Response to Comments - Final Task F Stage I - Part 2 Pilot Test Work Plan for VOC-Containing Alluvial Aquifer Groundwater</i> dated 11 July 2008), this action will be in compliance with DEQ-7.
ARM 17.30.1011	ARM 17.30.1011 provides that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality unless degradation may be allowed under the principles established in Section 75-5-303, MCA, and the nondegradation rules at ARM Title 17,chapter 30, subchapter 7.	
Surface Water Quality Standards (Applicable)		
Montana Water Quality Act, Section 75-5-101, et seq., MCA Federal Clean Water Act, 33 U.S.C. §§ 1251, et seq. ARM 17.30.611	The Montana Water Quality Act, Sections 75-5-101 et seq., establishes requirements for restoring and maintaining the quality of surface and ground waters and the federal Clean Water Act, 33 U.S.C. Sections 1251 et seq., establishes requirements for restoring and maintaining the quality of surface waters. Under these Acts the state has authority to adopt water quality standards designed to protect beneficial uses of each water body and to designate uses for each water body. Montana's regulations classify state waters according to quality, place restrictions on the discharge of pollutants to state waters and prohibit the degradation of state waters. ARM 17.30.611(1) (Applicable) provides that the waters of the Yellowstone River drainage upstream of the Laurel water supply intake, which includes the Livingston area, are classified "B-1" for water use.	To ensure state waters are not degraded/polluted, IDW generated during field activities associated with Task F will be managed as outlined in the Facility-Wide SAP. All purge water will be treated to the groundwater cleanup levels presented in the ROD and will meet all applicable permit requirements as specified in Petroleum Cleanup General Permit MTG7900013 before discharge to the Yellowstone River or disposed of according to the hazardous and solid waste procedures specified in the Facility-Wide SAP. Please refer to Attachment 1 of <i>Response to Comments - Final Task F Stage I - Part 2 Pilot Test Work Plan for VOC-Containing Alluvial Aquifer Groundwater</i> dated 11 July 2008.
ARM 17.30.623	ARM 17.30.623 provides that concentrations of carcinogenic, bioconcentrating, toxic or harmful parameters which would remain in the water after conventional water treatment may not exceed the applicable standards set forth in department Circular WQB-7.	
WQB-7 standards	WQB-7 provides that "For surface waters the Standard is the more restrictive of either the Aquatic Life Standard or the Human Health Standard." For the primary Contaminants of Concern the Circular WQB-7 standards are the same as listed above in groundwater.	
ARM 17.30.623	The B-1 classification standards at ARM 17.30.623 also include the following criteria: 1) Dissolved oxygen concentration must not be reduced below the levels given in department Circular WQB-7; 2) Hydrogen ion concentration (pH) must be maintained within the range of 6.5 to 9.5; 3) the maximum allowable increase above naturally occurring turbidity is 5 nephelometric turbidity units; 4) Temperature increases must be kept within prescribed limits; 5) No increase are allowed above naturally occurring concentrations of sediment, settleable solids, oils, floating solids, which will or is likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish or other wildlife. 6) True color must be kept within specified limits.	

ANALYSIS OF ENVIRONMENTAL REQUIREMENTS, CRITERIA, AND LIMITATIONS (ERCLS)^(a) FOR TASK F STAGE I - PART 2 PILOT TEST WORK PLAN
Burlington Northern Livingston Shop Complex

Federal or State ERCL Citation	Description	Compliance
ARM 17.30.637	ARM 17.30.637 which prohibits discharges containing substances that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; (b) create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials; (c) produce odors, colors or other conditions which create a nuisance or render undesirable tastes to fish flesh or make fish inedible; (d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life; (e) create conditions which produce undesirable aquatic life.	
ARM 17.30.705	ARM 17.30.705 provides that for any surface water, existing and anticipated uses and the water quality necessary to protect these uses must be maintained and protected unless degradation is allowed under the nondegradation rules at ARM 17.30.708.	<u>To ensure state waters are not degraded/polluted, IDW generated during field activities associated with Task F will be managed as outlined in the Facility-Wide SAP. All purge water will be treated to the groundwater cleanup levels presented in the ROD and will meet all applicable permit requirements as specified in Petroleum Cleanup General Permit MTG7900013 before discharge to the Yellowstone River or disposed of according to the hazardous and solid waste procedures specified in the Facility-Wide SAP.</u>
Water Quality Act, Title 17, Chapter 30, Sub-Chapters 6 and 13 and ARM 17.30.1332	<u>Stormwater Runoff (Applicable)</u> Pursuant to authority under the Water Quality Act, Title 17, Chapter 30, Sub-Chapter 6, and Title 17, Chapter 30, Sub-Chapter 13, including ARM 17.30.1332, the Water Quality Division issues general stormwater permits for certain activities. For construction activities, the following permit must be obtained: General Discharge Permit for Storm Water Associated with Construction Activity, Permit No. MTR100000 (May 19, 1997). Generally, the permits require the permittee to implement Best Management Practices (BMP) and to take all reasonable steps to minimize or prevent any discharge which has a reasonable likelihood of adversely affecting human health or the environment. However, if there is evidence indicating potential or realized impacts on water quality due to any storm water discharge associated with the activity, an individual MPDES permit or alternative general permit may be required.	Activities proposed in the pilot test work plan will not impact surface water runoff at the Facility.
Ambient Air Quality Standards (Applicable)		
40 CFR 50.12 and ARM 17.8.222	The following standards are applicable at the site ⁴ : 40 CFR 50.12 and ARM 17.8.222. Ambient air quality standard for lead. Lead concentrations in the ambient air shall not exceed the following 90-day average: 1.5 micrograms lead per cubic meter of air.	Activities proposed in this Work Plan will not result in exceedances of ambient air quality standards for lead or ozone.
40 CFR 50.9 and ARM 17.8.213	40 CFR 50.9 and ARM 17.8.213. Ambient air quality standard for ozone. No person shall cause or contribute to concentrations of ozone in the ambient air exceeding: 0.10 ppm 1-hour average (0.12 ppm federal standard). 40 CFR 50.10 establishes a daily maximum 8-hour average 0.08 parts per million (ppm).	
40 CFR 50.10		
ARM 17.8.220	ARM 17.8.220. Ambient air quality standard for settled particulate matter. Particulate matter concentrations in the ambient air shall not exceed the following 30-day average: 10 grams per square meter.	
40 CFR 50.6 and ARM 17.8.223	40 CFR 50.6 and ARM 17.8.223. Ambient air quality standards for PM-10. PM-10 concentrations in the ambient air shall not exceed the following standards: 150 micrograms/cubic meter of air, 24-hour average; and 50 micrograms/cubic meter of air, expected annual average.	<u>Activities proposed in this Work Plan include well installation and soil boring. However, these actions will include wetting and other best management practices related to fugitive dust control. Remedial actions will be halted if significant dust is generated and will not resume until adequate dust control measures are in place. These dust control measures will ensure that ambient air standards will not be exceeded during the proposed remedial action.</u>
40 CFR 50.8 and ARM 17.8.212	40 CFR 50.8 and ARM 17.8.212. Ambient air quality standards for carbon monoxide. Carbon monoxide concentrations in the ambient air shall not exceed the following standards: 9 ppm 8-hour average; and 23 ppm for a 1-hour average (35 ppm for federal).	Activities proposed in this Work Plan will not result in exceedances of ambient air quality standards for carbon monoxide.
Emission Standards (Applicable)		
Sections 75-2-101, et seq., MCA	Montana has promulgated standards to regulate emissions of certain contaminants into the air. The state emission standards are enforceable under the Montana Clean Air Act, Sections 75-2-101 et seq., MCA.	Activities proposed in the pilot test work plan will not result in volatile organic compound (VOC) emissions.
ARM 17.8.304	ARM 17.8.304. Visible Air Contaminants. No source may discharge emissions into the atmosphere that exhibit an opacity of 20 percent or greater, averaged over six consecutive minutes. This standard is limited to point sources, but excludes wood waste burners, incinerators, and motor vehicles.	
ARM 17.8.308	ARM 17.8.308. Airborne Particulate Matter. Emissions of airborne particulate matter from any stationary source shall not exhibit an opacity of 20 percent or greater, averaged over six consecutive minutes. This standard applies to the production, handling, transportation, or storage of any material; to the use of streets, roads, or parking lots; and to construction or demolition projects.	
ARM 17.8.315	ARM 17.8.315. Odors. If a business or other activity will create odors, those odors must be controlled, and no business or activity may cause a public nuisance.	Activities proposed in the pilot test work plan will not generate odors. No open burning will be conducted during implementation of the pilot test.
ARM 17.8.604	ARM 17.8.604. Prohibited open burning. Open burning of numerous specific materials, including but not limited to oil and petroleum products and hazardous wastes, is prohibited.	
ARM 17.8.705	ARM 17.8.705 requires that permits be obtained for the construction, installation, alteration, or use of specified air contaminant sources. All air permits required for remedial actions must be obtained.	Activities proposed in the pilot test work plan will not require air permits.
ARM 17.8.715	ARM 17.8.715 requires sources for which air quality permits are required to use best available control technology (BACT) or to meet the lowest achievable emission rate (LAER), as applicable.	
FEDERAL LOCATION SPECIFIC ERCLS		
Criteria Classification of Solid Waste Disposal Facilities and Practices (Applicable and Well-Suited)		
40 CFR 257	Under the selected remedy, no solid or hazardous waste (other than media treated to cleanup levels) may be disposed on-site. The standards therefore are pertinent to the cinder pile (well-suited) and placement of ex situ soils treated to cleanup levels (applicable) and post-jurisdictional wastes (applicable). The criteria contained in 40 CFR Part 257, establish standards with which solid waste disposal must comply to avoid possible adverse effects on health or the environment. 40 CFR Part 257 includes the following standards: Section 257.3-1(a) requires that facilities or practices in the floodplain not result in the washout of solid waste so as to pose a hazard to human life, wildlife, or land or water resources. Section 257.3-2 provides for the protection of threatened or endangered species. Section 257.3-3 provides that a facility shall not cause the discharge of pollutants into waters of the United States. Section 257.3-4 states that a facility or practice shall not contaminate underground drinking water.	Investigated derived waste (IDW) will be generated during implementation of the pilot test. Depending on the constituents and concentrations present and upon approval from the DEQ, this material may be landspread at the Livingston railyard, or treated, if feasible, and landspread at the Livingston railyard. Alternatively, the IDW will be disposed offsite at an appropriate permitted disposal facility. See the Facility-Wide SAP for additional information on how IDW generated during implementation of the pilot tests will be managed to comply with these ERCLs. Landspreading of soil and water, if approved by DEQ, will not occur in areas of a floodplain nor be conducted in a manner to cause discharge of pollutants into water. Other IDW or solid waste generated during implementation of the pilot tests will be disposed offsite at an appropriate permitted disposal facility.

Burlington Northern Livingston Shop Complex

Federal or State ERCL Citation	Description	Compliance
The Endangered Species Act (Well-Suited)		
16 U.S.C. §§ 1531 – 1544, 50 CFR Part 402, 40 CFR 6.302(h), 40 CFR 257.3-2	This statute and implementing regulations (16 U.S.C. § 1531 et seq., 50 CFR Part 402, 40 CFR 6.302(h), and 40 CFR 257.3-2) require that any federal activity or federally authorized activity may not jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify a critical habitat. Compliance with this requirement involves consultation with the U.S. Fish and Wildlife Service (USFWS) and a determination of whether there are listed or proposed species or critical habitats present at the Site, and, if so, whether any proposed activities will impact such wildlife or habitat. No endangered or threatened species was identified onsite although the Yellowstone Trout is treated as a species of special concern by the State. Any action affecting federal or State endangered or threatened species must comply with all listed requirements.	Activities proposed in the pilot test work plan will not impact endangered species. According to the ROD, no endangered species or threatened species were identified at the Facility, although the Yellowstone Trout is treated as a species of special concern by the State.
Sections 87-5-106, -107, -111, and -201, MCA	Sections 87-5-106, 107, and 111, MCA (Applicable): Endangered species should be protected in order to maintain and to the extent possible enhance their numbers. These sections list endangered species, prohibited acts and penalties. See also, §§ 87-5-106 and 87-5-201, MCA, (Applicable) concerning protection of wild birds, nests and eggs.	
ARM 12.5.201	ARM 12.5.201 (Applicable). Certain activities are prohibited with respect to specified endangered species.	
Migratory Bird Treaty Act (Well-Suited)		
16 U.S.C. §§ 703, et seq.	This requirement (16 U.S.C. § 703 et seq.) establishes a federal responsibility for the protection of the international migratory bird resource and requires continued consultation with the USFWS during remedial design and remedial action to ensure that the cleanup of the site does not unnecessarily impact migratory birds.	Activities proposed in the pilot test work plan will not impact migratory birds. Migratory birds may be present near the Facility. However, the Livingston railyard does not provide the majority of habitat for these species relative to the surrounding area, and no features exist that are particularly attractive to these species.
Bald Eagle Protection Act (Well-Suited)		
16 U.S.C. §§ 668, et seq.	This requirement (16 U.S.C. § 668 et seq.) establishes a federal responsibility for protection of bald and golden eagles, and requires continued consultation with the USFWS during remedial design and remedial action to ensure that any cleanup of the site does not unnecessarily adversely affect the bald and golden eagle.	Activities proposed in the pilot test work plan will not impact bald eagles. Bald eagles may be present near the Facility. However, the Livingston railyard does not provide the majority of habitat for these species relative to the surrounding area, and no features exist that are particularly attractive to these species.
Historic Sites, Buildings, Objects, and Antiquities Act (Well-Suited)		
16 U.S.C. 461, et seq.	These requirements, found at 16 U.S.C. 461 et seq., provide that, in conducting an environmental review of a proposed action, the responsible official shall consider the existence and location of natural landmarks using information provided by the National Park Service pursuant to 36 CFR 62.6(d) to avoid undesirable impacts upon such landmarks. No historic sites were identified.	Activities proposed in the pilot test work plan will not impact historic sites. According to the ROD, no historic sites were identified at the Livingston railyard.
Fish and Wildlife Coordination Act (Well-Suited)		
16 U.S.C. 661, et seq. and 40 CFR 6.302(g)	These standards are found at 16 U.S.C. § 661 et seq. and 40 CFR 6.302(g) and require that federally funded or authorized projects ensure that any modification of any stream or other water body affected by a funded or authorized action provide for adequate protection of fish and wildlife resources.	Activities proposed in the pilot test work plan do not involve the modification of any stream or other water body.
Floodplain Management Order (Well-Suited)		
40 CFR Part 6, Appendix A, Executive Order No. 11,988	This requirement (40 CFR Part 6, Appendix A, Executive Order No. 11,988) mandates that federally funded or authorized actions within the 100 year floodplain avoid, to the maximum extent possible, adverse impacts associated with development of a floodplain.	The proposed area(s) where the pilot test will be implemented and locations of the proposed new monitoring wells are not located in the floodway or floodplain. Therefore, the pilot test activities proposed in the pilot test work plan will not impact a floodway or floodplain. Figure H1 (attached) shows the portion of the Facility located within the 100-year floodplain.
Protection of Wetlands Order (Well-Suited)		
40 CFR Part 6, Appendix A, Executive Order No. 11,990 Section 404(b)(1), 33 U.S.C. Section 1344(b)(1)	This requirement (40 CFR Part 6, Appendix A, Executive Order No. 11,990) mandates that federal agencies and potentially responsible parties avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists. Section 404(b)(1), 33 U.S.C. § 1344(b)(1), also prohibits the discharge of dredged or fill material into waters of the United States. Together, these requirements create a "no net loss" of wetlands standard.	According to Montana's Natural Resource Information System, no wetlands have been identified in the Livingston area. Activities proposed in the pilot test work plan will not impact wetlands.
STATE LOCATION SPECIFIC ERCLS		
Solid Waste Management Regulations (Applicable and Well-Suited)		
Solid Waste Management Act, Sections 75-10-201 et seq., MCA	Regulations promulgated under the Solid Waste Management Act, Sections 75-10-201 et seq., MCA, specify requirements that apply to the location of any solid waste management facility. Under the selected remedy, no solid or hazardous waste (other than media treated to cleanup levels) may be disposed on-site. The standards therefore are pertinent to the cinder pile (well-suited) and placement of ex situ soils treated to cleanup levels (applicable) and post-jurisdictional wastes (applicable).	#####
ARM 17.50.505(1)	Under ARM 17.50.505(1), a facility for the treatment, storage or disposal of solid wastes: (a) must be located where a sufficient acreage of suitable land is available for solid waste management; (b) may not be located in a 100-year floodplain; (c) may be located only in areas which will prevent the pollution of ground and surface waters and public and private water supply systems; (d) must be located to allow for reclamation and reuse of the land; (e) drainage structures must be installed where necessary to prevent surface runoff from entering waste management areas; and (f) where underlying geological formations contain rock fractures or fissures which may lead to pollution of the ground water or areas in which springs exist that are hydraulically connected to a proposed disposal facility, only Class III disposal facilities may be approved.	Non-hazardous IDW generated during implementation of the pilot test will be contained in 55-gallon drums or other appropriate containers and stored inside/near the Former C&P Packing Building (see Section 8.4.4 1 of the Facility-Wide SAP). The Former C&P Packing Building and surrounding areas represent sufficient acreage for IDW management. The area is not located in a 100-year floodplain. IDW will be stored in appropriate containers to prevent pollution of groundwater, surface water, and public supply systems.

ANALYSIS OF ENVIRONMENTAL REQUIREMENTS, CRITERIA, AND LIMITATIONS (ERCLS)^(a) FOR TASK F STAGE I - PART 2 PILOT TEST WORK PLAN
Burlington Northern Livingston Shop Complex

Federal or State ERCL Citation	Description	Compliance
Floodplain and Floodway Management Act and Regulations (Applicable)		
Section 76-5-401, MCA and ARM 36.15.601	A portion of the site is in a designated floodplain. The following standards are included here to indicate the restrictions on any related activities that might occur in or affect the floodway or floodplain. Residential, certain agricultural, industrial-commercial, recreational and other uses are permissible within the designated floodway, provided they do not require structures other than portable structures, fill or permanent storage of materials or equipment. Section 76-5-401, MCA; ARM 36.15.601.	The proposed area(s) where the pilot test will be implemented and locations of the proposed new monitoring wells are not located in the floodway or floodplain. Therefore, the pilot test activities proposed in the pilot test work plan will not impact a floodway or floodplain. Figure H1 (attached) shows the portion of the Facility located within the 100-year floodplain.
Section 76-5-402, MCA and ARM 36.15.701	In the flood fringe (i.e., within the floodplain but outside the floodway), residential, commercial, industrial, and other structures may be permitted subject to certain conditions relating to placement of fill, roads, and floodproofing. Section 76-5-402, MCA; ARM 36.15.701.	
ARM 36.15.602(6)	Domestic water supply wells may be permitted, even within the floodway, provided the well casing and well meets certain conditions. ARM 36.15.602(6).	
ARM 36.15.602(5), 36.15.605, and 36.15.703	Solid and hazardous waste disposal and storage of toxic, flammable, hazardous, or explosive materials are prohibited anywhere in floodways or floodplains. ARM 36.15.602(5), 36.15.605, and 36.15.703.	
Section 76-5-402, MCA	The following are prohibited in a floodway: buildings for living purposes or place of assembly or permanent use by human beings; any structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway; and the construction or permanent storage of an object subject to flotation or movement during flood level periods. Section 76-5-402, MCA.	The proposed area(s) where the pilot test will be implemented and locations of the proposed new monitoring wells are not located in the floodway or floodplain. Therefore, the pilot test activities proposed in the pilot test work plan will not impact a floodway or floodplain. Figure H1 (attached) shows the portion of the Facility located within the 100-year floodplain.
Section 76-5-406, MCA and ARM 36.15.216	Section 76-5-406, MCA and ARM 36.15.216 contain substantive factors which address obstruction or use within the floodway or floodplain.	
ARM 36.15.604, ARM 36.15.602(1), and ARM 36.15.603	Further conditions or restrictions that generally apply to specific activities within the floodway or floodplain can be found at ARM 36.15.604 (increase in upstream elevation or significantly increase flood velocities); ARM 36.15.602(1) (excavation of material from pits or pools); ARM 36.15.603 (water diversions or changes in place of diversion).	
ARM 36.15.701(3)(c)	ARM 36.15.701(3)(c) requires that roads, streets, highways and rail lines must be designed to minimize increases in flood heights.	
ARM 36.15.701(3)(d)	Structures and facilities for liquid or solid waste treatment and disposal must be floodproofed to ensure that no pollutants enter flood waters and may be allowed and approved only in accordance with DEQ regulations, which include certain additional prohibitions on such disposal. ARM 36.15.701(3)(d).	
ARM 36.15.702(2)	Standards applied to residential, commercial or industrial structures are found at ARM 36.15.702(2).	
ARM 36.15.606	Flood control works are subject to ARM 36.15.606, which requires compliance with safety standards for levees, floodwalls, and riprap.	
ARM 36.15.901	ARM 36.15.901 requires electrical systems to be flood-proofed.	
FEDERAL AND STATE ACTION SPECIFIC ERCLS		
Federal Hazardous Waste Management Regulations (Applicable)		
42 U.S.C. §§ 6901 et seq., and Montana Hazardous Waste Act, Sections 75-10-401 et seq., MCA	The Resource Conservation and Recovery Act (RCRA), 42 U.S.C. Sections 6901 et seq., and the Montana Hazardous Waste Act, Sections 75-10-401 et seq., MCA, and regulations under these acts establish a regulatory structure for the generation, transportation, treatment, storage and disposal of hazardous wastes. These requirements are applicable to substances and actions at the site which involve the active management of hazardous wastes. Burlington Northern operated the site and generated waste through 1986-7. Therefore, in certain instances, disposal was not pre-jurisdictional and the hazardous waste requirements are applicable now. However, DEQ does not have the documentation showing the dates of individual discharges, and therefore has, for purposes of this ROD, made a determination to treat all historic waste and media containing waste as pre-jurisdictional (in accord with the NCP and EPA guidance). Therefore, under this ROD, the historic waste which is characteristic or listed becomes hazardous upon excavation (generation).	As discussed in Section 10.0 of the pilot test work plan, as the pilot test is being conducted in the area containing F-listed constituents, IDW generated during the pilot test will be suspected of containing F-listed constituents and will be managed as a hazardous waste unless analytical testing shows otherwise. The types of hazardous IDW expected to be generated are discussed in Section 10.0 of the work plan. Hazardous IDW will be managed in accordance with Section 10.0 of the pilot test work plan and with the Facility-Wide SAP. While DEQ has the authority to waive non-substantive permit requirements for remedial actions conducted entirely at the Facility, that authority does not extend to offsite permitted activities such as transporting and disposing of hazardous waste. Environmental samples containing RCRA-regulated constituents submitted to the analytical laboratory are exempt from RCRA; however, they become subject to RCRA again when they are disposed of by the analytical laboratory. Analytical laboratory will dispose of environmental samples in accordance with state and federal regulations.
Identification and Listing of Hazardous Waste		
40 CFR 261 ARM 17.54.501-502	Wastes may be designated as hazardous by either of two methods: listing or demonstration of a hazardous characteristic. Listed wastes are the specific types of wastes determined by EPA to be hazardous as identified in 40 CFR Part 261, Subpart D (40 CFR 261.30 - 261.33). Listed wastes are designated hazardous by virtue of their origin or source, and must be managed as hazardous wastes regardless of the concentration of hazardous constituents. Characteristic wastes are those that by virtue of concentrations of hazardous constituents demonstrate the characteristic of ignitability, corrosivity, reactivity or toxicity, as described at 40 CFR Part 261, Subpart C. Certain of the wastes at the site demonstrate the characteristic of toxicity, and are therefore characteristic hazardous wastes upon excavation. The site also contains F001 and F002 which are listed hazardous wastes for chlorinated solvents. The various media and wastes at the site contaminated by the F001 and F002 wastes are also hazardous wastes pursuant to 40 CFR Part 261 upon excavation. The RCRA requirements specified below are applicable requirements for the treatment, storage and disposal of these wastes. See 40 CFR 261.31 (Hazardous Waste Numbers F001 and F002) and ARM 17.54.501. These ERCLs apply to remedial activities; on-going operations must comply with State and federal requirements and permits. EPA has advised EPA Regions and States that conservative, health-based levels derived from direct exposure pathways would clearly be acceptable as "contained-in" levels. [See memorandum from Sylvia K. Lowrance to Jeff Zelikson, Region IX, (January 24, 1989)]. EPA and many States specify conservative, risk-based levels calculated with standard conservative exposure assumptions (usually based on unrestricted access), or site-specific risk assessments. 61 FR at 18795 (April 29, 1996); 63 FR 28556 (May 26, 1998) [Part I of II]. For the BN Livingston Shop Complex, soils treated to below cleanup levels will be allowed to return to the site (from, for example, the electric shop) to an approved location in compliance with RCRA.	As discussed in Section 10.0 of the pilot test work plan, as the pilot tests are being conducted in the area containing F-listed constituents, IDW generated during the pilot test will be suspected of containing F-listed constituents and will be managed as a hazardous waste unless analytical testing shows otherwise. Hazardous IDW will be managed in accordance with Section 10.0 of the pilot test work plan and with the Facility-Wide SAP. If offsite disposal is warranted, additional testing of the IDW may be required by the disposal facility and will be performed if necessary.
40 CFR 261 ARM 17.54.501-502 (cont.)	For media which contain hazardous waste, all standards are applicable except for disposal requirements for "contained-out" soils. For all non-media wastes, the standards are applicable. However, no on-site disposal of hazardous waste is allowed under the selected remedy. Therefore, all hazardous wastes, including all media not treated to cleanup levels must be disposed off-site at a regulated subtitle C facility. These standards specifically apply to free product removed from within the solvent plume. For free product removed from outside the solvent plume 40 CFR Part 279 is applicable.	

ANALYSIS OF ENVIRONMENTAL REQUIREMENTS, CRITERIA, AND LIMITATIONS (ERCLS)^(a) FOR TASK F STAGE I - PART 2 PILOT TEST WORK PLAN
Burlington Northern Livingston Shop Complex

Federal or State ERCL Citation	Description	Compliance
ARM 17.53.111 and 112, MCA	<p>Because of the presence of listed and characteristic hazardous waste, the permit requirements specified in ARM 17.53.112 are applicable. However, DEQ is exempting remedial actions involving hazardous waste from RCRA permit requirements pursuant to 75-10-721(3), MCA (1993) as long as substantive requirements are met. This does not, however, affect the requirement to comply with ARM 17.53.111, Registration and EPA Identification Numbers for Generators and Transporters.</p> <p>Workplans will require detailed information on compliance with all procedural and substantive standards (as well as all ERCLs).</p> <p>Set out below are the hazardous waste requirements that are applicable for the types of waste management units or the waste management practices anticipated in the remedial actions at the site.</p>	BNSF has obtained a hazardous waste identification number for the Livingston railyard (EPA ID No. MTT310010087).
Standards for Transporters of Hazardous Waste		
40 CFR Part 263	The RCRA regulations at 40 CFR Part 263, establish standards that apply to transporters of hazardous waste. These standards include requirements for immediate action for hazardous waste discharges. These standards are applicable for any on-site transportation. These standards are independently applicable (see Other Laws section) for any off-site transportation.	If hazardous waste needs to be transported outside the Facility, the waste will be manifested and a hazardous waste transporter will be used as discussed in Section 8.4.4 of the Facility-Wide SAP.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities		
40 CFR 264, Subpart B	<p><u>General Facility Standards</u></p> <p>The regulations at 40 CFR 264, Subpart B, establish general facility requirements. These standards include requirements for general waste analysis, security and location standards.</p>	Hazardous IDW will be managed in accordance with the Facility-Wide SAP.
40 CFR 264, Subpart F	<p><u>Releases from Solid Waste Management Units</u></p> <p>The regulations at 40 CFR 264, Subpart F, establish requirements for groundwater protection for RCRA-regulated solid waste management units (i.e., waste piles, surface impoundments, land treatment units, and landfills). The regulations at Subpart F establish monitoring requirements for RCRA-regulated solid waste management units (i.e., waste piles, surface impoundments, land treatment units, and landfills). Subpart F provides for three general types of groundwater monitoring: detection monitoring (40 CFR 264.98); compliance monitoring (40 CFR 264.99); and corrective action monitoring (40 CFR 264.100). Monitoring wells must be cased according to 264.97(c).</p> <p>Monitoring is required during the active life of a hazardous waste management unit. If hazardous waste remains, monitoring is required for a period necessary to protect human health and the environment.</p>	<p><u>Hazardous IDW will be managed in accordance with the Facility-Wide SAP.</u></p>
40 CFR Part 264, Subpart G	<p><u>Closure and Post-Closure Monitoring and Maintenance of Waste Management or Disposal Facilities</u></p> <p>40 CFR Part 264, Subpart G, establishes that hazardous waste management facilities must be closed in such a manner as to (a) minimize the need for further maintenance and (b) control, minimize or eliminate, to the extent necessary to protect public health and the environment, post-closure escape of hazardous wastes, hazardous constituents, leachate, contaminated runoff or hazardous waste decomposition products to the ground or surface waters or to the atmosphere.</p> <p>Requirements for facilities requiring post-closure care include the following: the facilities must undertake appropriate monitoring and maintenance actions, control public access, and control postclosure use of the property to ensure that the integrity of the final cover, liner, or containment system is not disturbed. In addition, all contaminated equipment, structures and soil must be properly disposed of or decontaminated unless exempt and free liquids must be removed or solidified, the wastes stabilized, and the waste management unit covered.</p>	
40 CFR Part 264, Subparts I and J 40 CFR 261.7	<p><u>Waste Containers and Tanks</u></p> <p>40 CFR Part 264, Subparts I and J apply to owners and operators of facilities that store hazardous waste in containers, and store or treat hazardous waste in tanks, respectively. These regulations are applicable to any storage or treatment in these units at the site. The related provisions of 40 CFR 261.7, residues of hazardous waste in empty containers, are also applicable.</p>	Hazardous IDW and IDW suspected to be hazardous generated during implementation of the pilot test will be stored in drums, tanks, or other appropriate containers and managed as outlined in the Facility-Wide SAP.
40 CFR Part 264, Subpart L	<p><u>Waste Piles</u></p> <p>40 CFR Part 264, Subpart L, applies to owners and operators of facilities that store or treat hazardous waste in piles. The regulations include requirements for the use of run-on and run-off control systems and collection and holding systems to prevent the release of contaminants from waste piles. These regulations are applicable to any storage in waste piles at the site.</p>	IDW generated during implementation of the pilot test will not be stored in waste piles. IDW (soil, water, non-indigenous) generated during the pilot tests will be stored in drums, tank(s) or other appropriate containers as described in Section 8.4 of the Facility-Wide SAP.
40 CFR 264.554	<p><u>Staging Piles</u></p> <p>40 CFR 264.554 sets forth a new storage unit called the staging pile. A staging pile must be located within the contiguous property under the control of the owner/operator where the wastes to be managed in the staging pile originated. The staging pile must be designed so as to prevent or minimize releases of hazardous wastes and hazardous constituents into the environment, and minimize or adequately control cross-media transfer, as necessary to protect human health and the environment (for example, through the use of liners, covers, run-off/run-on controls, as appropriate). The staging pile must not operate for more than two years and cannot be used for treatment.</p>	IDW generated during implementation of the pilot test will not be stored in staging piles. IDW (soil, water, non-indigenous) generated during the pilot tests will be stored in drums, tank(s) or other appropriate containers as described in Section 8.4 of the Facility-Wide SAP.
40 CFR Part 268	<p><u>RCRA Land Disposal Restrictions</u></p> <p>Since the wastes to be treated are listed and characteristic wastes, the RCRA Land Disposal Restrictions (LDRs) treatment levels set forth in 40 CFR Part 268 are applicable requirements including the treatment levels for F001 and F002 listed wastes for the disposal of hazardous wastes generated at the site. With the exception of treated soils, hazardous wastes are prohibited from disposal on-site.</p>	If investigation-derived soil or water is proposed for landspreading, documentation showing that concentrations are below LDR standards will be included in the request for a written contained-in determination as discussed in the Facility-Wide SAP.
HWIR Media Rule (63 Fed. Reg. 65874)	The HWIR Media Rule, promulgated at 63 Fed. Reg. 65874 (November 30, 1998) allows listed waste treated to levels protective of human health and the environment to be disposed on-site without triggering land ban or minimum technology requirements for these disposal requirements. Treated soils containing hazardous waste will need to meet cleanup levels to avoid triggering land ban or minimum technology requirements for these disposal requirements.	
40 CFR 268.45	<p><u>Hazardous debris</u></p> <p>Since on-site disposal of solid and hazardous wastes is prohibited at the site, any hazardous debris remaining on-site must comply with 40 CFR 268.45 prior to off-site disposal as a solid waste (all off-site disposal must also comply with LDR certification requirements, which apply to these wastes). If the debris does not fully comply with 40 CFR 268.45, it must be disposed off-site at a regulated subtitle C facility.</p>	If hazardous debris is generated during activities proposed in the pilot test work plan, they will be managed as a hazardous waste along with hazardous IDW as outlined in the Facility-Wide SAP.
40 CFR Part 270	<p><u>Substantive Permit Requirements</u></p> <p>40 CFR Part 270 sets forth the hazardous waste permit program. The substantive requirements set forth in 40 CFR Part 270, Subpart C (permit conditions), including the requirement to properly operate and maintain all facilities and systems of treatment and control are applicable requirements.</p>	The substantive permit requirements that pertain to the management of hazardous waste (including generation, storage, and disposal) are included in the Facility-Wide SAP.
40 CFR Part 279	<p><u>Used Oil</u></p> <p>40 CFR Part 279 sets forth the standards for the management of used oil. For product removed from outside the solvent plume, 40 CFR Part 279 is applicable.</p>	Activities proposed in the pilot test work plan will not result in the generation of used oil.

ANALYSIS OF ENVIRONMENTAL REQUIREMENTS, CRITERIA, AND LIMITATIONS (ERCLS)^(a) FOR TASK F STAGE I - PART 2 PILOT TEST WORK PLAN
Burlington Northern Livingston Shop Complex

Federal or State ERCL Citation	Description	Compliance
State Hazardous Waste Management Regulations (Applicable)		
Sections 75-10-401 et seq., MCA	The Montana Hazardous Waste Act, Sections 75-10-401 et seq., MCA, and regulations under this act establishes a regulatory structure for the generation, transportation, treatment, storage and disposal of hazardous wastes. These requirements are applicable to substances and actions at the site which involve listed and characteristic hazardous wastes.	As discussed in Section 10.0 of the pilot test work plan, as the pilot tests are being conducted in an area containing F-listed constituents, IDW generated during the pilot tests will be suspected of containing F-listed constituents and will be managed as a hazardous waste unless analytical testing shows otherwise. Hazardous IDW will be managed in accordance with Section 10.0 of the work plan and with the Facility-Wide SAP.
ARM 17.53.501-502	ARM 17.53.501-502 adopts the equivalent of RCRA regulations at 40 CFR Part 261, establishing standards for the identification and listing of hazardous wastes, including standards for recyclable materials and standards for empty containers, with certain State exceptions and additions.	
ARM 17.53.601-604	ARM 17.53.601-604, adopts the equivalent to RCRA regulations at 40 CFR Part 262, establishing standards that apply to generators of hazardous waste, including standards pertaining to the accumulation of hazardous wastes, with certain State exceptions and additions.	
ARM 17.53.701-708	ARM 17.53.701-708, adopts the equivalent to RCRA regulations at 40 CFR Part 263, establishing standards that apply to transporters of hazardous waste, with certain State exceptions and additions.	
ARM 17.53.801-803	ARM 17.53.801-803, adopts the equivalent to RCRA regulations at 40 CFR Part 264, establishing standards that apply to hazardous waste treatment, storage and disposal facilities, with certain State exceptions and additions.	
ARM 17.53.1101-1102	ARM 17.53.1101-1102, adopts the equivalent to RCRA regulations at 40 CFR Part 268, establishing land disposal restrictions, with certain State exceptions and additions.	
Section 75-10-422 MCA	Section 75-10-422 MCA prohibits the unlawful disposal of hazardous wastes.	
ARM 17.53.1101-1102	ARM 17.53.1101-1102, adopts the equivalent to RCRA regulations at 40 CFR Part 270, which establish standards for permitted facilities, with certain State exceptions and additions.	
ARM 17.53.1401	ARM 17.53.1401, adopts the equivalent of RCRA regulations at 40 CFR Part 279 which set forth the standards for the management of used oil.	Activities proposed in the pilot test work plan will not result in the generation of used oil.
National Emission Standards for Hazardous Air Pollutants (NESHAPs)		
ARM 17.8.341 (Incorporates by reference 40 CFR Part 61)	<u>Asbestos (Well-Suited)</u> The federal Clean Air Act requires the EPA to set emission standards for hazardous air pollutants. 42 U.S.C Section 7412. Implementation and enforcement of these standards in Montana has been delegated to the State. See 40 CFR 61.04(b)(BB). Federal standards for hazardous air pollutants (NESHAPs) at 40 CFR Part 61, are incorporated by reference by ARM 17.8.341. The NESHAPs for asbestos are well-suited to the cinder pile and are discussed in the Asbestos section below; however, the solid waste requirements are the more stringent of the ERCLs that must be complied with with respect to covering of the cinder pile.	Activities proposed in the pilot test work plan will not result in air emissions of asbestos.
40 CFR 61.145	40 CFR 61.145. (well-suited). Standard for demolition and renovation. This section contains standards for demolition or renovation of a facility. The standards are designed to reduce or eliminate asbestos emissions from such operations, and include provisions for notification regarding intended project, wetting of asbestos materials, use of exhaust systems, careful movement of asbestos materials, and presence on site of a trained asbestos removal person. This section applies to any demolition or renovation of a structure, installation, building, or waste disposal area at the site containing asbestos materials.	
40 CFR 61.151	40 CFR 61.151. (well-suited). Standard for inactive waste disposal sites for asbestos mills and manufacturing and fabricating operations. There must either be no discharge of visible emissions from the site to the outside air, or the specified covering or treatment methods must be followed. Warning signs must be posted and prior notice must be given to EPA or the State before the waste material is excavated or disturbed.	
40 CFR Part 61, Subpart F	<u>Vinyl Chloride (Applicable)</u> 40 CFR Part 61, Subpart F contains the national emission standard for vinyl chloride. 40 CFR 61.64(b) requires concentrations from vinyl chloride in each exhaust gas stream from each stripper not exceed 10 ppm.	Activities proposed in the pilot test work plan will not result in air emissions of vinyl chloride.
National Pollutant Discharge Elimination System (NPDES) and the Montana Pollutant Discharge Elimination System (MPDES) (Applicable)		
40 CFR Part 122, Subpart C and ARM 17.30.1342 - .1344	40 CFR Part 122, Subpart C and ARM 17.30.1342-1344 set forth the substantive requirements applicable to all MPDES and NPDES permits. Permits must be obtained for all surface and groundwater systems that are part of remedial actions, including proper operation and maintenance of all facilities and systems of treatment and control.	Activities proposed in the pilot test work plan will not result in any surface water discharge(s).
Technology-Based Treatment (Applicable)		
40 CFR Part 125 and ARM 17.30.1344	40 CFR Part 125 and ARM 17.30.1344 set forth criteria and standards for dischargers. Based on the source, the technology-based treatment standards include the best practicable control technology (BPT), best conventional pollutant control technology (BCT), or Best Available Technology Economically Achievable (BAT).	<u>To ensure state waters are not degraded/polluted, all purge water will be treated to the groundwater cleanup levels presented in the Record of Decision (ROD) (DEQ 2001) and will meet all applicable permit requirements as specified in Petroleum Cleanup General Permit MTG7900013 before discharge to the Yellowstone River.</u>
Underground Injection Control Program (Well-Suited)		
40 CFR 146	The Underground Injection Control Program set forth at 40 CFR 146, sets forth the standards and criteria for the injection of substances into aquifers. Wells are classified as Class I through V, depending on the location and the type of substance injected. For all classes, no owner may construct, operate or maintain an injection well in a manner that results in the contamination of an underground source of drinking water at levels that violate MCLs or otherwise adversely affect the health of persons. Each classification may also contain further specific standards, depending on the classification.	Activities proposed in the pilot test work plan involve the construction/operation of boreholes for injection of reagents related to environmental remediation. These are not subject to underground injection control permitting and are most likely rule-permitted. However, if requested by EPA, information required and any mitigation measures will be provided for discussion.

ANALYSIS OF ENVIRONMENTAL REQUIREMENTS, CRITERIA, AND LIMITATIONS (ERCLS)^(a) FOR TASK F STAGE I - PART 2 PILOT TEST WORK PLAN
Burlington Northern Livingston Shop Complex

Federal or State ERCL Citation	Description	Compliance
Solid Waste Management Regulation (Applicable and Well-Suited)		
ARM 17.50.505	ARM 17.50.505(2) specifies standards for solid waste management facilities, including the requirements that: 1. Class II landfills must confine solid waste and leachate to the disposal facility. If there is the potential for leachate migration, it must be demonstrated that leachate will only migrate to underlying formations which have no hydraulic continuity with any state waters; 2. adequate separation of group II wastes from underlying or adjacent water must be provided; and 3. no new disposal units or lateral expansions may be located in wetlands. ARM 17.50.505 also specifies general soil and hydrogeological requirements pertaining to the location of any solid waste management facility.	Activities proposed in the pilot test work plan do not involve siting, construction, operation/maintenance, and closure of a solid waste management facility.
ARM 17.50.511	ARM 17.50.511 sets forth general operational and maintenance and design requirements for solid waste facilities using landfilling methods. Specific operational requirements, specified in ARM 17.14.511 are run-on and run-off control systems requirements, requirements that sites be fenced to prevent unauthorized access, and prohibitions of point source and nonpoint source discharges which would violate Clean Water Act requirements.	
ARM 17.50.530	ARM 17.50.530 sets forth the closure requirements for landfills. Class II landfills must meet the following criteria: 1. install a final cover that is designed to minimize infiltration and erosion. 2. design and construct the final cover system to minimize infiltration through the closed unit by the use of an infiltration layer that contains a minimum 18 inches of earthen material and has a permeability less than or equal to the permeability of any bottom liner, barrier layer, or natural subsoils or a permeability no greater than 1 X 10-5 cm/sec, whichever is less; 3. minimize erosion of the final cover by the use of a seed bed layer that contains a minimum of six inches of earthen material that is capable of sustaining native plant growth and protecting the infiltration layer from frost effects and rooting damage; 4. revegetate the final cover with native plant growth within one year of placement of the final cover. ⁵	
ARM 17.50.531	ARM 17.50.531 sets forth post closure care requirements for Class II landfills. Post closure care must be conducted for a period sufficient to protect human health and the environment. Post closure care requires maintenance of the integrity and effectiveness of any final cover, including making repairs to the cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the cover and comply with the groundwater monitoring requirements found at ARM Title 17, chapter 14, subchapter 7.	
Transportation of Solid Waste (Applicable)		
Section 75-10-212	For solid wastes, Section 75-10-212 prohibits dumping or leaving any debris or refuse upon or within 200 yards of any highway, road, street, or alley of the State or other public property, or on privately owned property where hunting, fishing, or other recreation is permitted.	Non-hazardous IDW [including non-indigenous waste (i.e., PPE) and IDW determined through analytical testing to be non-hazardous] generated during implementation of the pilot tests will be contained in 55-gallon drums or other appropriate containers and temporarily stored in a centralized storage area pending characterization and final disposition. If investigation-derived soil and water cannot landspread at the Livingston railyard, it will be disposed offsite along with other non-hazardous IDW as discussed in the Facility-Wide SAP. Any other solid waste generated (i.e., tape removed from boxes, plastic bags and/or boxes containing supplies that are not reused, etc.) will be contained in a plastic garbage bag (if necessary) and placed in a garbage can for collection and appropriate disposal as solid waste. Solid waste generated during implementation of pilot test will be transported in a manner to prevent discharge, dumping, spilling, and leaking.
ARM 17.50.523	ARM 17.50.523 requires that such waste must be transported in such a manner as to prevent its discharge, dumping, spilling, or leaking from the transport vehicle.	
Underground Storage Tank (USTs) Regulations (Applicable)		
	These standards are applicable. To the extent certain UST systems were removed prior to the effective date of the regulations, diesel is found separate and distinct from an UST system, or UST regulations are not applicable, the UST requirements remain well-suited since they address situations or problems sufficiently similar to those at the site.	Activities proposed in the pilot test work plan do not involve USTs.
40 CFR Part 280, Subpart F	40 CFR Part 280, Subpart F sets forth requirements for Release Response and Corrective Action for UST Systems Containing Petroleum or Hazardous Substances. These include initial response, initial abatement measures, site characterization, free product removal, and investigations for soil and groundwater cleanup.	
40 CFR 280.64	40 CFR 280.64 provides that where investigations in connection with leaking underground storage tanks reveal the presence of free product, owners and operators must remove free product to the maximum extent practicable as determined by the implementing agency. This regulation also requires that the free product removal be conducted in a manner that minimizes the spread of contamination into previously uncontaminated zones by using recovery and disposal techniques appropriate to the hydrogeologic conditions at the site, and that properly treats, discharges or disposes of recovery byproducts in compliance with applicable local, State and Federal regulations. 40 CFR 280.64 provides that abatement of free product migration is a minimum objective for the design of the free product removal system provides that any flammable products must be handled in a safe and competent manner to prevent fires or explosions.	
40 CFR Part 280, Subpart D	40 CFR Part 280, Subpart D sets forth requirements for release detection.	
40 CFR 280.43	40 CFR 280.43 (well-suited) specifies groundwater monitoring requirements for underground storage tanks and requires continuous monitoring devices or manual methods used to detect the presence of at least 1/8 of an inch of free product on top of the groundwater in the monitoring wells.	
Title 17, Chapter 56, Sub-Chapter 4	The Montana regulations regarding underground storage tanks include similar requirements. Title 17, Chapter 56, Sub-Chapter 4 specifies release detection.	
ARM 17.56.407	ARM 17.56.407 specifies groundwater monitoring requirements for underground storage tanks and requires continuous monitoring devices or manual methods used to detect the presence of at least 1/8 of an inch of free product on top of the groundwater in the monitoring wells.	
Title 17, Chapter 56, Sub-Chapter 6	Title 17, Chapter 56, Sub-Chapter 6 specifies release response and corrective action for tanks containing petroleum or hazardous substances.	
ARM 17.56.602 - 605	ARM 17.56.602 through 605 requires certain mitigation measures including removal of as much of the regulated substance from the system as is necessary to prevent further release into the environment and prevention of further migration of the released substance into surrounding soil and groundwater.	

ANALYSIS OF ENVIRONMENTAL REQUIREMENTS, CRITERIA, AND LIMITATIONS (ERCLS)^(a) FOR TASK F STAGE I - PART 2 PILOT TEST WORK PLAN
Burlington Northern Livingston Shop Complex

Federal or State ERCL Citation	Description	Compliance
Asbestos Regulation in Building Construction and Demolition (Well-Suited)		
Sections 50-64-101, et seq., MCA 50-64-104, MCA	Sections 50-64-101 et seq., MCA, regulate construction and demolition of structures that contain asbestos. Section 50-64-104, MCA, provides for various safeguards to prevent release of asbestos into the air. The prescribed safeguards include notification of the local fire department, posting of warning signs, wetting of surfaces, dust emission control, covering and wetting during transport, and deposition at a landfill where materials are unlikely to be disturbed and where signs warn that asbestos-containing material is buried in the landfill. The listed safeguards are well-suited to the covering of the cinder pile.	Activities proposed in the pilot test work plan do not involve construction or demolition of any asbestos-containing structures.
Well Drilling (Applicable)		
Section 85-2-505, MCA	Section 85-2-505, MCA, precludes the wasting of groundwater. Any well producing waters that contaminate other waters must be plugged or capped, and wells must be constructed and maintained so as to prevent waste, contamination, or pollution of groundwater.	Activities proposed in the pilot test work plan involve the installation of wells. Wells will be constructed and maintained so as to prevent waste, contamination, or pollution of groundwater. Wells will be constructed and sampled in accordance with Standard Operating Guidelines (SOGs) presented in Appendix A of the Facility-Wide SAP. Drillers will be required to file a well log report within 60 days after completion of the well. <u>The statute now requires that the well logs be filed with the Montana Bureau of Mines and Geology, which will be done.</u>
Section 85-2-516, MCA	Section 85-2-516, MCA states that within 60 days after any well is completed a well log report must be filed by the driller with the Montana Department of Natural Resources and Conservation and the appropriate county clerk and recorder.	
ARM 17.30.641	ARM 17.30.641 provides standards for sampling and analysis of water to determine quality.	
ARM 17.30.646	ARM 17.30.646 requires that bioassay tolerance concentrations be determined in a specified manner.	
ARM 36.21.670-678 and 810	ARM 36.21.670-678 and 810 specifies certain requirements that must be fulfilled when abandoning monitoring wells.	If wells are to be abandoned following completion of the pilot tests, they will be abandoned in accordance with SOG-20 (presented in Appendix A of the Facility-Wide SAP), which complies with these regulations.
Reclamation Requirements (Well-Suited)		
	Certain portions of the Montana Strip and Underground Mining Reclamation Act and Montana Metal Mining Act are well-suited requirements for certain revegetation and construction activities at the site.	Activities proposed in the pilot test work plan do not involve any major land disturbances, which trigger these requirements.
Section 82-4-231, MCA	Section 82-4-231, MCA: Requires operators to reclaim and revegetate affected lands using most modern technology available.	
Section 82-4-233, MCA	Section 82-4-233, MCA: Operators must plant vegetation that will yield a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area and capable of self-regeneration.	
Section 82-4-336, MCA	Section 82-4-336, MCA: Disturbed areas must be reclaimed to utility and stability comparable to areas adjacent.	
ARM 17.24.501	ARM 17.24.501: Provides general backfilling and grading requirements.	
ARM 17.24.519	ARM 17.24.519: Pertinent areas where excavation will occur will be regraded to minimize settlement.	
ARM 17.24.631	ARM 17.24.631: Disturbances to the prevailing hydrologic balance will be minimized. Changes in water quality and quantity, in the depth to groundwater and in the location of surface water drainage channels will be minimized, to the extent consistent with the selected response alternatives. Other pollution minimization devices must be used if appropriate, including stabilizing disturbed areas through land shaping, diverting runoff, planting quickly germinating and growing stands of temporary vegetation, mulching, and control of toxic-forming waste materials.	
ARM 17.24.633	ARM 17.24.633: Surface drainage from a disturbed area must be treated by the best technology currently available (BTCA). Treatment must continue until the area is stabilized.	
ARM 17.24.634	ARM 17.24.634: Disturbed drainages will be restored to the approximate pre-disturbance configuration, to the extent consistent with the selected response alternatives.	
ARM 17.24.638	ARM 17.24.638: Sediment control measures must be implemented during operations.	
ARM 17.24.639	ARM 17.24.639: Sets forth requirements for construction and maintenance of sedimentation ponds.	
ARM 17.24.640	ARM 17.24.640: Discharges from sedimentation ponds, permanent and temporary impoundments, must be controlled to reduce erosion and enlargement of stream channels, and to minimize disturbance of the hydrologic balance.	
ARM 17.24.643 - 646	ARM 17.24.643 through 17.24.646: Provisions for groundwater protection, groundwater recharge protection, and groundwater and surface water monitoring.	
ARM 17.24.701 and 702	ARM 17.24.701 and 702: Requirements for redistributing and stockpiling of soil for reclamation. Also outline practices to prevent compaction, slippage, erosion, and deterioration of biological properties of soil will be employed.	
ARM 17.24.711	ARM 17.24.711: Requires that a diverse, effective and permanent vegetative cover of the same seasonal variety and utility as the vegetation native to the area of land to be affected must be established. This provision would not be well-suited in certain instances, for example, where there is dedicated development.	
ARM 17.24.713	ARM 17.24.713: Seeding and planting of disturbed areas must be conducted during the first appropriate period for favorable planting after final seedbed.	
ARM 17.24.714	ARM 17.24.714: Mulch or cover crop or both must be used until adequate permanent cover can be established.	
ARM 17.24.716	ARM 17.24.716: Establishes method of revegetation.	
ARM 17.24.718	ARM 17.24.718: Requires soil amendments, irrigation, management, fencing, or other measures, if necessary to establish a diverse and permanent vegetative cover.	
ARM 17.24.723	ARM 17.24.723: States that operators shall conduct approved periodic measurements of vegetation, soils, and water.	
ARM 17.24.724	ARM 17.24.724: Specifies that revegetation success must be measured by approved unmined reference areas. Required management for these reference areas is set forth.	
ARM 17.24.726	ARM 17.24.726: Sets the required methods for measuring productivity.	
ARM 17.24.728	ARM 17.24.728: Sets requirements for measurements of the composition of vegetation on reclaimed areas.	
ARM 17.24.761	ARM 17.24.761: This specifies fugitive dust control measures which will be employed during excavation and construction activities to minimize the emission of fugitive dust.	

ANALYSIS OF ENVIRONMENTAL REQUIREMENTS, CRITERIA, AND LIMITATIONS (ERCLS)^(a) FOR TASK F STAGE I - PART 2 PILOT TEST WORK PLAN
Burlington Northern Livingston Shop Complex

Federal or State ERCL Citation	Description	Compliance
Noxious Weeds (Applicable)		
ARM 4.5.201 through .204 Section 7-22-2109(2)(b) Section 7-22-2152 Section 7-22-2101(7)(a), MCA	§ 7-22-2101(7)(a), MCA defines "noxious weeds" as any exotic plant species established or that may be introduced in the state which may render land unfit for agriculture, forestry, livestock, wildlife, or other beneficial uses or that may harm native plant communities and that is designated: (i) as a statewide noxious weed by rule of the department; or (ii) as a district noxious weed by a board, following public notice of intent and a public hearing. Designated noxious weeds are listed in ARM 4.5.201 through 4.5.204 and must be managed consistent with weed management criteria developed under MCA § 7-22-2109(2)(b). Notification and plan must occur as set forth in § 7-22-2152, MCA, as amended.	Activities proposed in the pilot test work plan do not involve the introduction or planting of plants, nor will significant land disturbance occur which would trigger these requirements.
OTHER LAWS		
	These laws are laws which are independently applicable rather than ERCLs for the site.	
Section 85-2-101, MCA	<u>Surface Water and Groundwater Act</u> Section 85-2-101, MCA, declares that all waters within the state are the state's property, and may be appropriated for beneficial uses. The wise use of water resources is encouraged for the maximum benefit to the people and with minimum degradation of natural aquatic ecosystems.	Activities proposed in the pilot test work plan will not require any surface water or groundwater to be appropriated.
Parts 3 and 4 of Title 85, Chapter 2, MCA	<u>Groundwater and Surface Water Appropriation</u> Parts 3 and 4 of Title 85, Chapter 2, MCA, set out requirements for obtaining water rights and appropriating and utilizing water. All requirements of these parts are laws which must be complied with in any action using or affecting waters of the state.	Activities proposed in the pilot test work plan will not require any water rights to be obtained.
Section 85-2-507, MCA Section 85-2-506, MCA	<u>Controlled Ground Water Area</u> Pursuant to Section 85-2-507 MCA, the Department of Natural Resources and Conservation may grant either a permanent or a temporary controlled ground water area. The maximum allowable time for a temporary area is four years. ⁶ Pursuant to 85-2-506 MCA, designation of a controlled groundwater area may be proposed if (a) that ground water withdrawals are in excess of recharge to the aquifer or aquifers within the ground water area; (b) that excessive ground water withdrawals are very likely to occur in the near future because of consistent and significant increases in withdrawals from within the ground water area; (c) that significant disputes regarding priority of rights, amounts of ground water in use by appropriators, or priority of type of use are in progress within the ground water area; (d) that ground water levels or pressures in the area in question are declining or have declined excessively; (e) that excessive ground water withdrawals would cause contaminant migration; (f) that ground water withdrawals adversely affecting ground water quality within the ground water area are occurring or are likely to occur; or (g) that water quality within the ground water area is not suited for a specific beneficial use defined by 85-2-102(2)(a).	Activities proposed in the pilot test work plan will not require a controlled groundwater area.
29 CFR Part 1910	<u>Occupational Safety and Health Act</u> The federal Occupational Safety and Health Act regulations found at 29 CFR 1910 are applicable to worker protection during conduct of RI/FS or remedial activities.	Field activities associated with the pilot test will be conducted in accordance with the <i>Facility-Wide Health and Safety Plan</i> (HASP) and the task-specific HASP addenda.
ARM 17.74.101 ARM 17.74.102	<u>Montana Occupational Health Act</u> ARM Section 17.74.101, along with the similar federal standard in 29 CFR 1910.95, addresses occupational noise. ARM Section 17.74.102, along with the similar federal standard in 29 CFR 1910.1000 addresses occupational air contaminants.	
Sections 50-71-201, 202, and 203, MCA	<u>Montana Safety Act</u> Sections 50-71-201, 202 and 203, MCA, state that every employer must provide and maintain a safe place of employment, provide and require use of safety devices and safeguards, and ensure that operations and processes are reasonably adequate to render the place of employment safe.	
Section 50-78-201, 202, and 204, MCA	<u>Employee and Community Hazardous Chemical Information Act</u> Sections 50-78-201, 202, and 204, MCA, state that each employer must post notice of employee rights, maintain at the work place a list of chemical names of each chemical in the work place, and indicate the work area where the chemical is stored or used. Employees must be informed of the chemicals at the work place and trained in the proper handling of the chemicals.	Kennedy/Jenks Consultants has a comprehensive Injury and Illness Prevention Program designed to help ensure the health and safety of its employees and provide a safe and healthful work environment. In addition, Kennedy/Jenks Consultants has a Corporate Health and Safety Program and Hazardous Communication Program.
40 CFR Part 262 and ARM 17.53.601-604	<u>Standards for Generators of Hazardous Waste</u> The RCRA regulations at 40 CFR Part 262 and ARM 17.53.601-604 establish standards that apply to generators of hazardous waste. These standards include requirements for obtaining an EPA identification number and maintaining certain records and filing certain reports. These standards are applicable for any waste which will transported off-site.	Hazardous IDW generated during implementation of the pilot test will be managed in accordance with Section 8.4 of the Facility-Wide SAP and will comply with these regulations.
40 CFR Part 263 and ARM 17.53.701-708	<u>Standards for Transporters of Hazardous Waste</u> The RCRA regulations at 40 CFR Part 263 and ARM 17.53.701-708 establish standards that apply to transporters of hazardous waste. These standards include requirements for immediate action for hazardous waste discharges. These standards are applicable for any off-site transportation.	
40 CFR 268 and ARM 17.53.1101-1102	<u>RCRA Land Disposal Restrictions</u> Since the wastes to be treated are listed and characteristic wastes, the RCRA Land Disposal Restrictions (LDRs) treatment levels set forth in 40 CFR Part 268 and ARM 17.53.1101-1102 are applicable requirements including the treatment levels for F001 and F002 listed wastes for the disposal of hazardous wastes generated at the site.	
49 CFR Chapter I, Subchapters B and C and ARM 23.5.101	<u>Oil Transportation</u> 49 CFR Chapter I, Subchapter B (Oil Transportation) and Subchapter C (Hazardous Materials) and ARM. 23.5.101 apply to transporters of oil and hazardous materials. These standards are applicable for any off-site transportation of oil meeting the quantity requirements set forth in Subchapter B or for the transportation of hazardous materials such as the transportation of asbestos-containing waste material.	Activities proposed in the pilot test work plan do not involve the use of oil and will not generate used oil.

ANALYSIS OF ENVIRONMENTAL REQUIREMENTS, CRITERIA, AND LIMITATIONS (ERCLS)^(a) FOR TASK F STAGE I - PART 2 PILOT TEST WORK PLAN
Burlington Northern Livingston Shop Complex

Federal or State ERCL Citation	Description	Compliance
Sections 75-2-501 et seq., Sections 75-2-502(4) and -511, MCA, and ARM 17.74.302(3) ARM 17.74.314 ARM 17.74.335 29 CFR 1926.58 40 CFR 763.120-121 40 CFR Part 61, Subpart M ARM 17.74.338 ARM 17.74.341	<u>Montana Asbestos Control Act</u> The Montana Asbestos Control Act, Sections 75-2-501 et seq., MCA, and implementing rules establish standards and procedures for accreditation of asbestos-related occupations and control of the work performed by persons in asbestos-related occupations. A permit from DEQ is required before any person can conduct an asbestos project. The definition of "asbestos project" includes the encapsulation, enclosure, removal, transportation, or disposal of asbestos-containing waste. Section 75-2-502(4), MCA; ARM 17.74.302(3). In addition, a person who inspects, plans, designs, supervises, contracts for or works on an asbestos project must meet DEQ training and accreditation requirements. See also Section 75-2-511, MCA. ARM 17.74.314 states that no person may engage in an asbestos-type occupation unless accredited in that occupation or may employ or subcontract with nonaccredited individuals or contractors. No person may conduct an asbestos abatement project without a permit. ARM 17.74.335 states that asbestos abatement projects require a DEQ permit. The permit conditions include but are not limited to: a. a requirement that all work performed be in accordance with 29 CFR 1926.58 (asbestos standards for the construction industry); and 40 CFR 763.120, 121 (requirements for asbestos abatement projects); b. a requirement that all asbestos be properly disposed in an approved asbestos disposal facility. "Approved asbestos disposal facility" is defined at ARM 17.54.302(1) as a properly operated and licensed class II landfill as described in ARM 17.50.504; c. a requirement that asbestos be disposed in accordance with 40 CFR Part 61, Subpart M. (National Emission Standard for Asbestos). See discussion above on National Emission Standard for Asbestos. ARM 17.74.338 requires an accredited asbestos abatement supervisor be physically present at all times at the work-site where a permitted asbestos abatement project is being performed and must be accessible to all workers. On-site air monitoring must be conducted by an accredited asbestos contractor/supervisor, an engineer or industrial hygienist. ARM 17.74.341 requires records of each asbestos abatement project be retained for a minimum of 30 years and must be made available to DEQ at any reasonable time. This section provides a noninclusive list of the records to be retained.	Activities proposed in the pilot test work plan do not involve asbestos work.
40 CFR Part 92	<u>Locomotive Emissions</u> 40 CFR Part 92 establishes control of air pollution from locomotives and locomotive engines.	Activities proposed in the pilot test work plan do not involve the use of locomotives.

Notes:

(a) These ERCLs were developed by the Montana Department of Environmental Quality and were included in Appendix A of the *Record of Decision* (ROD) (DEQ 2001). ERCLs pertinent to *Task F Stage I - Part 2 Pilot Test Work Plan for VOC-Containing Alluvial Aquifer Groundwater* are shaded in yellow.

¹ *Montana Maximum Contaminant Levels:*
Pursuant to the Public Water Safety Act, 75-6-101 et. seq., MCA and ARM 17.38.204, the MCLs specified in 40 CFR Part 141 (Primary Drinking Water Standards) are incorporated.

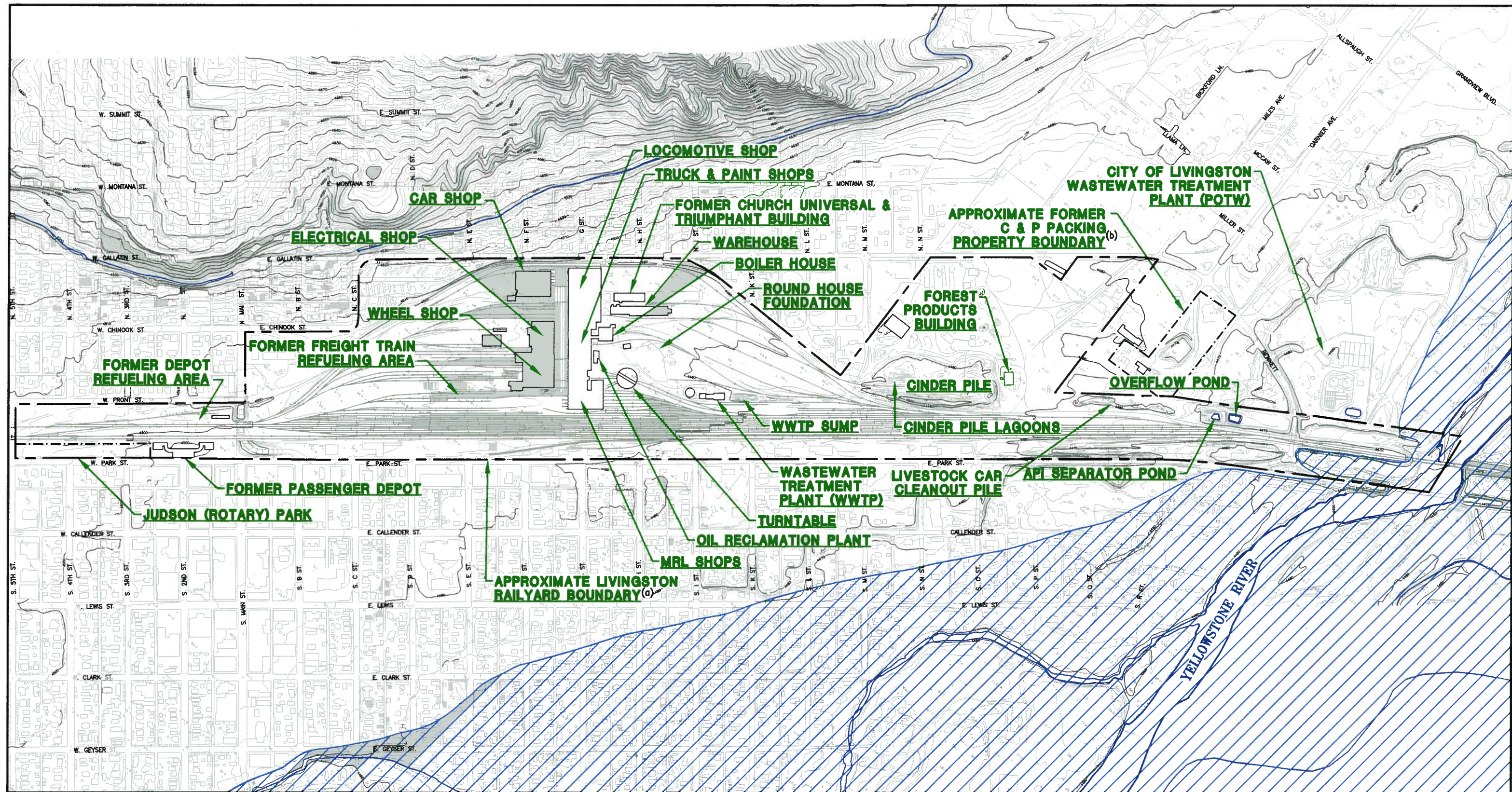
² *Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Circular WQB-7, Montana Numeric Water Quality Standards (September, 1999).*

³ *For vinyl chloride, the WQB-7 standard was 0.15 ug/l; the MCL is 2 ug/l.*

⁴ *Each of the ambient air quality standards includes in its terms specific requirements and methodologies for monitoring and determining levels. Such requirements are also applicable requirements. In addition, ARM 17.8.204 and 17.8.206, Ambient Air Monitoring; Methods and Data, respectively (Applicable), require that all ambient air monitoring, sampling and data collection, recording, analysis and transmittal shall be in compliance with the Montana Quality Assurance Manual except when more stringent requirements are determined by DEQ to be necessary.*

⁵ *ARM 17.50.530(1)(b) allows the department to approve an alternative final cover design if it achieves the reduction in infiltration and protection from erosion to a level at least as equivalent as the stated criteria.*

⁶ *If a temporary controlled ground water area is granted, the statute requires DNRC to commence studies to determine the designation or modification of a permanent controlled ground water area.*



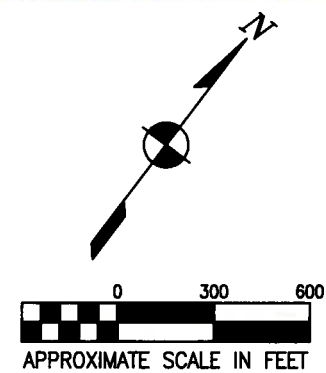
NOTES:

- (a) DENOTES BOUNDARY OF LIVINGSTON RAILYARD AND DOES NOT REPRESENT THE FACILITY BOUNDARY AS DEFINED UNDER MONTANA'S COMPREHENSIVE ENVIRONMENTAL CLEANUP AND RESPONSIBILITY ACT (CECRA).
- (b) APPROXIMATE BOUNDARY TAKEN FROM 2ND DRAFT C & P PACKING INVESTIGATION WORK PLAN, LIVINGSTON, MT. PREPARED BY ENVIROCON, INC., MISSOULA, MT, DATED 14 JUNE 2001

LEGEND:

 APPROXIMATE 100 - YEAR FLOOD HAZARD AREA (FEMA 1987)

BASEMAP SOURCE:
HORIZONS, INC. RAPID CITY, SD (1989)



Kennedy/Jenks Consultants

BURLINGTON NORTHERN LIVINGSTON SHOP
COMPLEX - LIVINGSTON, MT

100 - YEAR FLOOD HAZARD AREA

0896021.16/TASK F/PT WP/FIGURE H1r1

6/08 (REVISION NO. 1)

FIGURE H1